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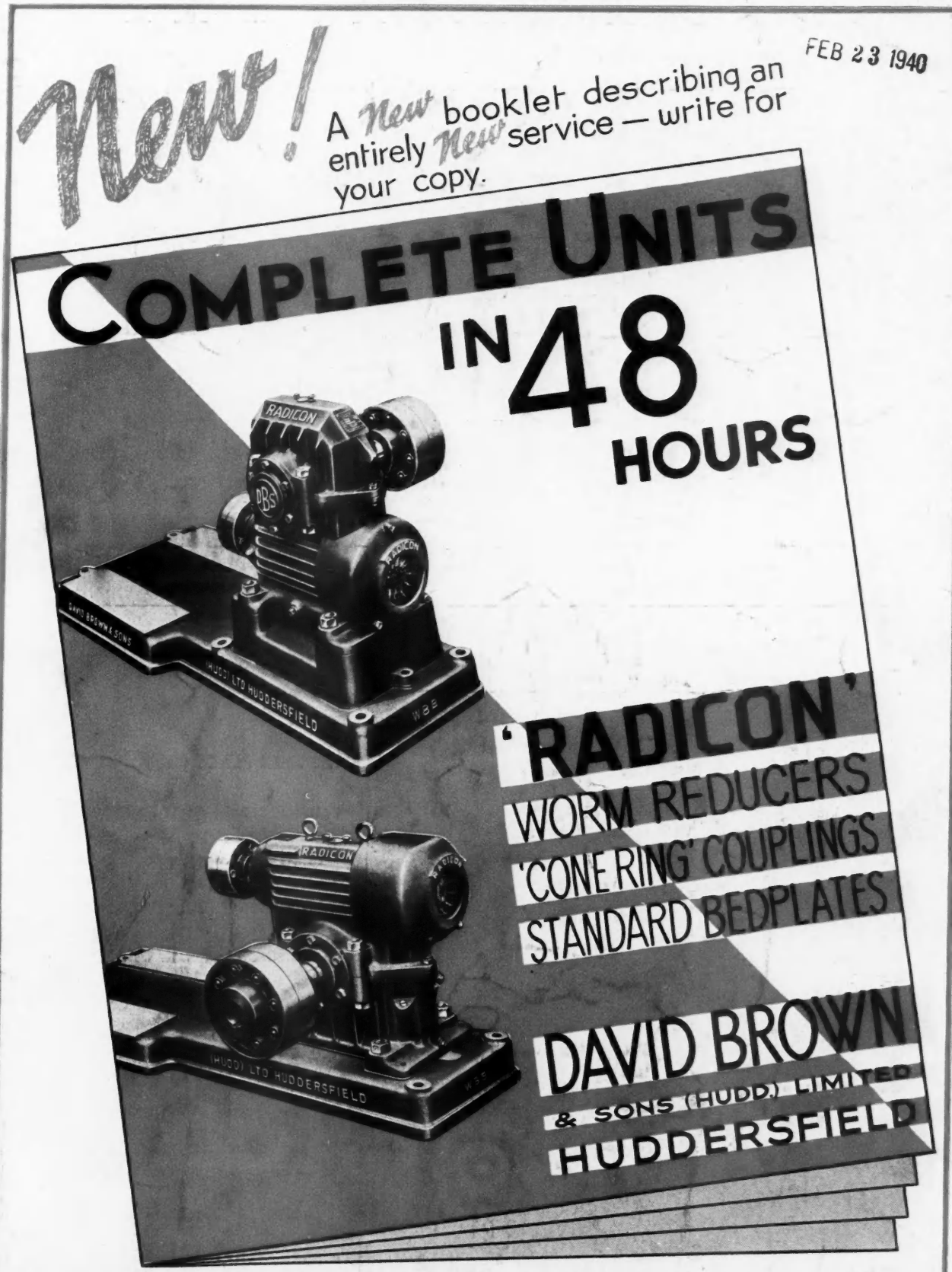

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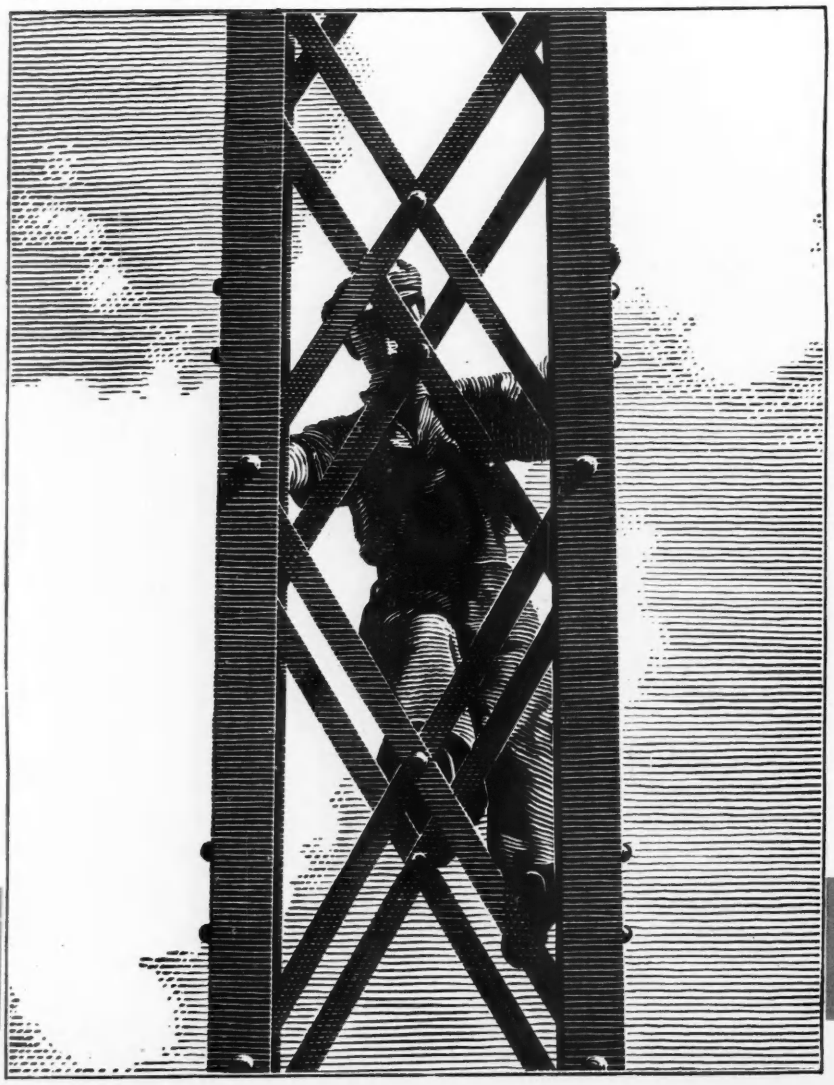

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British Corporation Technical Committee

THE announcement is made that, on account of the many other demands upon his time, Sir Maurice Denny, Bt., has resigned his appointment as chairman of the Technical Committee of the British Corporation Register of Shipping and Aircraft, which he has occupied with distinction for fifteen years. He will be succeeded by Mr. A. Murray Stephen, who is a leading figure in Clyde shipbuilding, and like Sir Maurice, a past-president of the Shipbuilding Employers' Federation. At a recent meeting held in Glasgow, Mr. Gilbert J. Innes, the chairman of the Corporation, spoke of the valuable services which Sir Maurice had rendered to the society during his long tenure of office. That period, Mr. Innes said, had seen far reaching developments in ship design and construction, marine engineering, and metallurgy. Sir Maurice took an active part in the Corporation's pioneer work in connection with the inspection of Civil aircraft, and was chairman of the Aviation Committee for close upon ten years. When in 1937 that work was taken over by the Air Registration Board, Sir Maurice, who was the nominee of the British Corporation, was elected its chairman. It is satisfactory to learn that Sir Maurice will continue to be a member of the Committee of Management, and the Technical Committee of the Corporation, so that his expert knowledge and wide practical experience will remain at the society's disposal. The appointment of Mr. Murray Stephen to succeed Sir Maurice Denny continues the long association of the Denny and Stephen families with the work of the British Corporation. It may be recalled that within a year of its foundation the late Sir Archibald Denny became, in 1890, the chairman of the Technical Committee and continued in office until 1907, when he was succeeded by the late Mr. Fred Stephen, who held that position until 1925, when he was succeeded by Sir Maurice Denny, who is now followed by another member of the Stephen family.

F.B.I. and War Risks Insurance

IN a letter to the Board of Trade on premiums to be charged under Part II of the War Risks (Commodities) Insurance Act, the Federation of British Industries strongly urges that for one month, starting from March 3 next, the existing amounts of risk should be covered without payment of an additional premium. It is pointed out that, when the scheme was inaugurated last September, at a time when immediate claims upon the fund were contemplated, it was considered sufficient to establish a fund equal to 30s. per cent. for the three-month period September 3rd to December 2nd. Yet by March 3rd, the date on which the next period begins, a fund will have been created equal to 35s. per cent. on the value of stocks insured. In these circumstances, the F.B.I. feels that the cash resources of industry need not be further depleted by a call for additional premiums, though it fully recognises that, in the event of severe damage, the existing fund may have to be increased. The Federation further draws the attention of the Board of Trade to the fact that confusion has arisen from the ruling that, where a contract is for work, labour, and materials rather than for a sale of goods, the goods required for carrying out the contract are not insurable under the Act. To remove the prevailing uncertainty, the Federation suggests that the Act should be amended to provide that, whether or not the contract includes an element of service, commodities should be insurable up to the time of delivery to the site (under a constructional contract) or to the customer in other cases, except when ownership has passed earlier to the purchasers. This arrangement would not affect goods excluded from the Act by order of the Board of Trade, or such work as structural contracts which are now outside its scope. Were the Act amended in this sense, it would be of great assistance if Government Departments would adopt a uniform practice in dealing with war risk charges in their contracts.

A Call For Workers

ON Saturday, January 27th, Mr. Winston Churchill, First Lord of the Admiralty, addressed an audience of 2500 people in the Free Trade Hall, Manchester, on the war effort. He reviewed the work of the Navy since the outbreak of war. The first attack of the U-boats had been mastered, and deadly losses had been inflicted on them. At least half the U-boats with which the enemy began the war had been destroyed, and their new building had so far fallen far short of what we had originally estimated. We had no doubt that the mining menace would be severe and costly to meet, but our science was superior in several very important ways to that of the enemy, and we saw no reason why the mining menace should not be brought under control as effectively as it was in the last war. Referring to the mobilisation of our labour and field forces, he said that we had much slack to take up. Indeed, the greater part of our national life had to be turned over from peace to war. We had not taken up all our slack yet, or there would not still be 1,300,000 unemployed of whom at least half could play their part. We could not place in the field immediately the great armies which we needed, which we were determined to form, and for which millions of eager men stood ready. We had to increase very largely our manufacture of munitions and equipment of all kinds. The immense plants and factories needed could only gradually come into full production. We had to make a huge expansion of our labour force, and especially of those capable of performing skilled or semi-skilled operations. There we had specially to count for aid and guidance upon our Labour colleagues and trade union leaders. Millions of new workers would be needed, and more than a million women must come boldly forth into our war industry, into the shell plants and ammunition works, and into the aircraft industry. If trade unionists, from patriotic or international motives, laid aside for the duration of the war any of the special craft usages which they had so carefully built up, they would need to have no fear that these would not be fully restored to them after the war was won.

The Late Sir Arthur Jackson

SIR ARTHUR JACKSON, M. Inst. C.E., died suddenly on Jan. 21st at Stonegate his country residence near Tunbridge Wells. He was 65 years of age. Sir Arthur spent all his life in civil engineering contracting. He was educated at Fettes College, Edinburgh, and became an engineering pupil under Thomas Meik and Sons, civil engineers, Westminster. He was for many years a Director and Managing Director of Sir John Jackson, Ltd., and joined the company in 1892. With Sir John Jackson, Ltd., he was connected with the construction of the Admiralty dockyard and harbour works at Keyham, Devonport, the Admiralty harbour works, Simonstown, South Africa, Singapore harbour works for the Straits Government, the Nag Hammadi barrage, Egypt, and other works of a world wide character, and latterly the construction of the Singapore naval base for the Admiralty, for which he received his knighthood.

Women in War Industry

ON Monday, January 29th, Mr. Fred A. Smith, general secretary of the Amalgamated Engineering Union, commented on Mr. Churchill's call, summarised in another Journal Note, for millions of new workers, and more than a million women workers, in the war industries. Mr. Smith said that the Amalgamated Engineering Union was and always had been opposed to the introduction of women into the industry. No application for the employment of women had been made by the Government, nor had the union had any official communication from the employers on the subject. Not with the consent of the union would women be brought in in normal times. If they did come to the question of bringing in women workers, because of the national emergency, and women were employed on certain unskilled work, the union would insist that they should be paid exactly the same as men. If the powers that be were genuine in their protestations, there would be no desire to create a cheap labour force. Referring to Mr. Churchill's figure of a million women, Mr. Smith said that if Mr. Churchill knocked off a nought it would make a big difference. He then asked where was the floor space and machinery for them, and what was to be done about men who were working short time on their ordinary jobs. Every available ounce of labour and every available engineering factory, however small, must be brought in. A fundamental thing, which the council of the A.E.U. would bear in mind, was that the men of the industry had a right to their places in the industry when things were normal. There must be complete restoration of all conditions which might be relaxed during the war.

War Time Scientific Research

ON Thursday, January 25th, the first meeting of the Advisory Council on Scientific Research and Technical Development was held at the Ministry of Supply. In the absence of Mr. Burgin, the Minister of Supply, Colonel J. J. Llewellin opened the meeting. He said that the Ministry already had a very extensive Directorate of Scientific Research, which served all three Defence Departments. The Ministry had also been able to supplement the resources of the directorate with extensive assistance from research laboratories in universities and industry. The Advisory Council, of which Lord Cadman was chairman, would be the senior advisory body of the Ministry upon all matters of pure and applied science. The Ministry looked upon the council not only to help to make weapons superior to those of the enemy and to indicate efficient antidotes to any "secret" war weapons we may have to meet, but also to assist if possible in the development of new processes of rapid production. It was hoped, too, that the council might be able to assist in the appropriate utilisation and conservation of raw materials and the discovery of substitutes for materials wherever that might be desirable. Lord Cadman said that the council had an extensive research programme before it, which included more than a thousand items for investigation. The range of subjects covered the most exacting chemical work in the explosives section and the most refined physical research in the communications section. Because of the variety of subjects to be dealt with it was essential to have a council membership of not less than 25 and to have many committees of the council on which outside scientists would also serve. With the impetus which it was hoped the council would give to military research they would, no doubt, have some proposals of a major character. It was expected that the committees would recommend changes in existing researches, both in nature and the financial provision needed for them. The Ministry of Supply, Directorate of Scientific Research, had a personnel of about 900, but even so there was plenty of ability outside the permanent staff capable of helping and willing to do so. The directorate was so constituted that advantage could be taken at any time of outside facilities and outside personnel could be engaged for investigatory work.

Fuel Supplies for Gas Producers

A SPECIFICATION for transport producer gas fuels has been issued by the Producer Gas Fuels Committee of the Coal and Carbonisation Industries Research Station. The growing use of producer gas in place of petrol or diesel oil for road vehicles will, it is hoped, receive a new impetus from the publication of this official specification for suitable fuels and of directions for obtaining them. The specification is the work of a committee which was set up shortly after the outbreak of war by the Coal and Carbonisation Industries under the chairmanship of Mr. Herman Lindars. Represented on the committee are the Mining Association of Great Britain, the gas and coke industries and the low temperature carbonisation industry, while a link exists with the British Coal Utilisation Research Association through Mr. Lindars, who is also chairman of the council of that body. Apart from much needed technical improvements in the design of producers themselves, to which the committee is giving every encouragement, the greatest need in this important system is an abundant supply and adequate distribution of suitable fuels. Notwithstanding the interest among transport operators which has been aroused by the work of the Hartley Committee and the demonstrations of successful plant made by the manufacturers of commercial units, transport operators are reluctant to consider any widespread changeover to producer gas until they know that they can rely upon supplies of fuel of the correct quality. The official specification now published provides assurances on this point and it is also understood that the committee is taking steps to meet the desire of transport operators for a uniform policy throughout the country as regards price and distribution. Transport operators and others desiring particulars with regard to fuel supplies should communicate with the Secretary, Producer Gas Fuels Committee of the Coal and Carbonisation Industries, 9, Rickett Street, London, S.W.6.

Black-Out Road Dangers

ON Monday, January 29th, Mr. Euan Wallace, Minister of Transport, spoke about a campaign to reduce road accidents, which reached the highest figures ever recorded in the first four months of the war. Successive Governments, he said, had endeavoured to deal with this toll of suffering and waste. The 30 m.p.h. speed limit in built-up areas, driving tests, pedestrian crossings, and similar measures had checked the growth of the accident figures in spite of a constant increase in the number of vehicles on the roads. While the number of motor-vehicles increased by 28 per cent. between 1934 and 1938, the accident figures remained steady from 1935 to 1938 inclusive at a little over 6500 killed and 220,000 injured. But now we were faced with a more difficult programme. During the last four months of 1939, 4133 persons died as a result of road accidents, making 8270 for the year, the highest recorded. Out of a total of 1155 fatal accidents in December, no fewer than 895 resulted from accidents in the dark. It was proposed to deal with the matter, so far as the motor-driver was concerned, by imposing a 20 m.p.h. speed limit in built-up areas at night. He had always held the view that the toll of road casualties, in peace or in war, could be reduced by the use of judicious propaganda. The campaign would be directed chiefly to helping the pedestrian, because he was the worst sufferer, and, under black-out conditions, it lay in his hands to make the greatest contribution to safety. Every pedestrian should remember that during the black-out he could see the lights of an approaching vehicle long before the driver could see him. Propaganda instruments would include the Press, films, leaflets, posters, and public meetings.

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Remote Supervisory Control on the Wirral Railway

No. I

THE Wirral railway electrification scheme to which the Automatic Telephone and Electric Company's supervisory remote control system has been applied was described in a general way in our issue of March 18th, 1938. Prior to that time there was no direct connection at Birkenhead Park station between the electric trains of the Mersey railway, and the steam trains of the Wirral system. But with the completion of the electrification scheme, through trains were run between Liverpool Central station and each of the two sections of the Wirral railway, *i.e.* New Brighton and West Kirby. One of the advantages of the

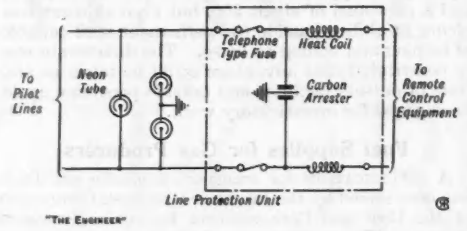


FIG. 1—PROTECTIVE ARRANGEMENTS

completed electrification scheme is that the large number of through passengers have no longer to tolerate the inconvenience of having to change trains at Birkenhead Park station.

Electrically the entire scheme is in two portions, one being the original electrified line of the Mersey railway, and the other the electrified Wirral railway. The supply of current to the former portion of the scheme is under the control of the Mersey railway authorities, whilst the latter electrified portion derives its current from the Liverpool Corporation's 11-kV 3-phase 50-cycle system and is transformed down and rectified for traction purposes at six unattended sub-stations. The last-named are completely supervised and controlled from the control room switchboard at the same site as the Birkenhead North sub-station.

From the Liverpool Corporation, the 11-kV 3-phase supply is given by two independent feeder cables run through the Mersey railway tunnel to the Birkenhead North sub-station. Each of these feeders terminates in an oil-filled circuit breaker feeding on to bus bars, from which single 3-phase lines extend to the sub-stations at Bidston and Wallasey, and a twin circuit to Moreton sub-station. This twin circuit is terminated at Moreton in a similar manner to the incoming feeders at Birkenhead North sub-station, single 3-phase lines being extended from bus bars at Moreton to the sub-stations at Meols and Hoylake. At Birkenhead North and Moreton, the oil-filled circuit breakers are interlocked so that it is impossible to parallel the two incoming supplies by means of the bus coupler, which can only be closed when one feeder is open.

At each sub-station a small transformer for auxiliary supplies and station lighting is connected to the 11 kV bus bars through a switch fuse. Each sub-station has a D.C. output of 600 kW at 650 volts from Hewittic glass bulb 6-phase mercury arc rectifiers. The main transformer for the rectifiers at each sub-station is connected to the 11 kV supply by means of an oil circuit breaker, the secondary winding being directly connected to the rectifiers, whilst the star point of that winding is bonded to the negative return rail, with an ammeter shunt connected in series for metering purposes. The D.C. output of the rectifiers is fed through a single pole high-speed circuit breaker to the positive bus bar from whence the various feeders to the track are supplied through individual circuit breakers of the same type.

Facilities provided by the remote supervisory control and supervisory equipment are as follows :—(*a*) Indication and remote control of the various A.C. and D.C. circuit breakers in the sub-stations. On the control switchboard a pair of red and green miniature lamps is provided for each circuit breaker, the red lamp glowing to indicate when the circuit breaker is closed whilst the green lamp indicates when it is open. A telephone type key is associated with each pair of red and green lamps and actuation of this key enables the corresponding distant circuit breaker to be "selected" by the automatic equipment and subsequently closed or tripped by the depression of a common operating key on the control switchboard. The supervisory

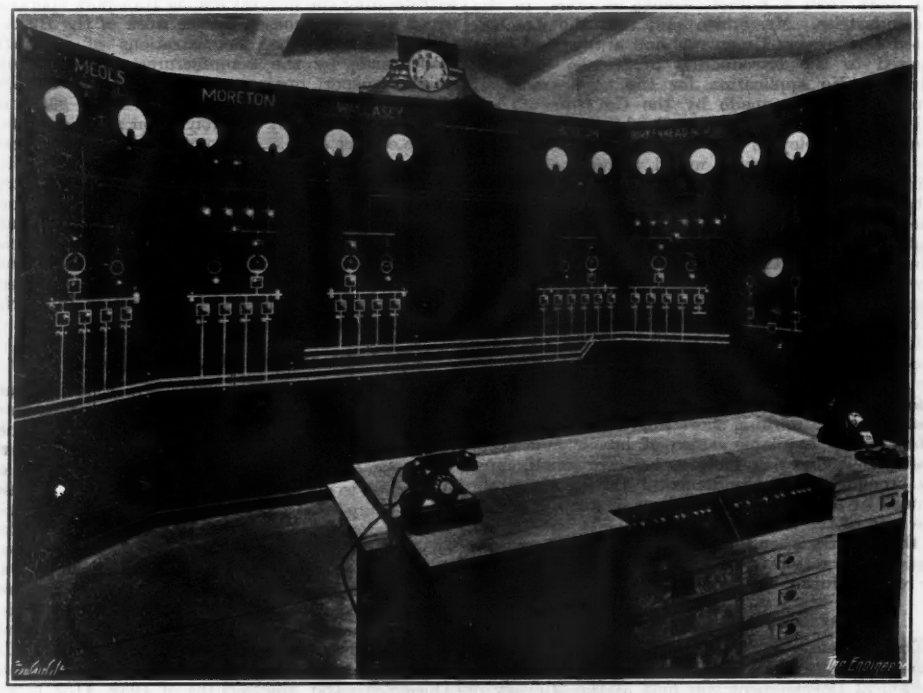


FIG. 2—CONTROL ARRANGEMENTS

remote control equipment provides in all for the indication, selection, and operation of 51 individual circuit breakers ; (*b*) Indication. An alarm relay is connected to the low tension A.C. supply feeding the station platform lights, &c., at each sub-station, and any failure of this supply releases the alarm relay and causes an indication of the fact to be displayed at the control room ; (*c*) Remote metering. Strowger photo-telemetering transmitters are provided at each of the five remote sub-stations and actuate corresponding receiving meters at the control room, this system operating on the selection principle to be described later.

The circuit arrangements are such that circuit breakers have priority over metering indications. Hence, in the event of any circuit breaker being tripped during metering conditions, the metering indications are discontinued until the automatic equipment has indicated the changed circuit breaker condition to the control room. Telephone connections and metering indications are however carried on simultaneously ; (*d*) Telephone communication is provided between the control room, and each sub-station, and also between any two

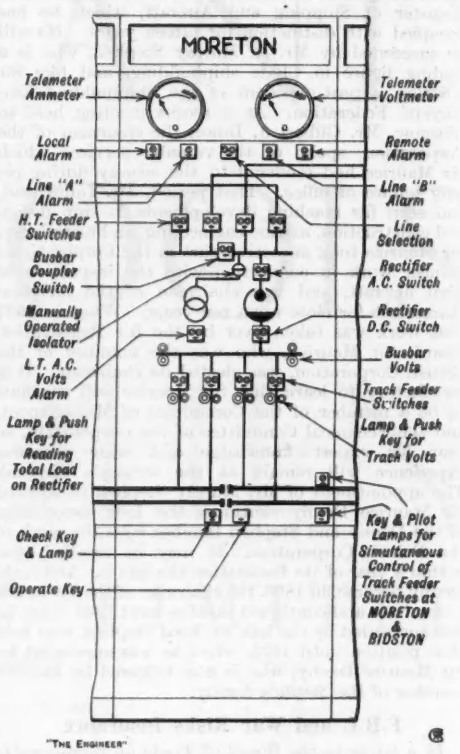


FIG. 3—DETAILS OF MORETON SUB-STATION PANEL

sub-stations *via* the control room. Various extension telephones are connected to each sub-station, and each of them may be selected and called from the control room by means of the automatic code ringing equipment.

While two pairs of pilot wires are provided for supervisory remote control purposes, only one pair is in use at any one time, the other pair serving as a stand-by. The pilot wires each consist of a phosphor bronze conductor weighing

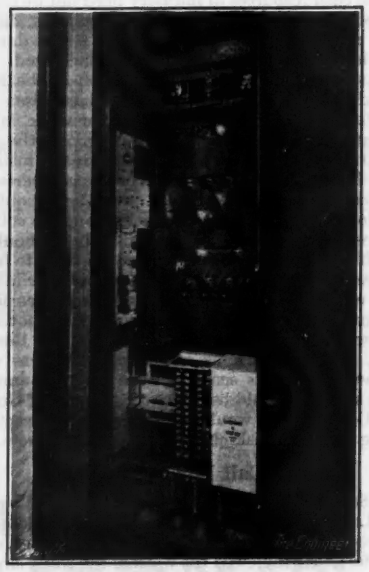


FIG. 4—SUPERVISORY REMOTE CONTROL APPARATUS IN CONTROL ROOM

200 lb. per mile, insulated with paper, cotton, and a weather-proofed jute braiding overall. The four conductors erected on existing telegraph poles are transposed at every pole as a precaution against inductive interference from the E.H.T. feeder circuits on the other side of the track, and also from the D.C. live rail. Protection of the pilot wires against induced voltages is provided in part by gas discharge tubes, connected across the incoming and outgoing ends at each sub-station, and also by B.P.O. subscriber's line protector units, as shown in Fig. 1. Both pairs of

pilot wires are continuously supervised, an alarm signal being automatically given in the control room in the event of a disconnection or short circuit occurring on either pair. At the control room, simple means are provided for changing over from one pair of pilot wires to the other.

The control room switchboard (Fig. 2) has eight self-contained sections, each section comprising an angle iron framework, fitted with a steel sheet panel at the front and a hinged "Plymax" door at the rear. At the top of each section are an ammeter and voltmeter, and immediately above these instruments sub-station nameplates, each comprising a glass panel finished to match the steel panels, and having the sub-station names stencilled and arranged for illumination behind. Telephone type indicating lamps and control keys on the panels are mounted so that the fixings are invisible from the front. Six of the eight sections of the switchboard contain the control equipment for the six sub-stations, together with their corresponding line diagrams. One of the remaining two panels is a spare whilst the other panel accommodates the equipment associated with the incoming E.H.T. feeders from the Harrington Street sub-station of the Liverpool Corporation. At the top of the latter panel are two voltmeters for indicating the pressure of the incoming feeders, whilst a maximum demand indicator and the line diagram of the Harrington Street sub-station are accommodated in the centre. In this case the sub-station circuit breakers are not indicated by miniature lamps, since these particular breakers are not remotely controlled. Small hand operated two-position semaphores are used instead, and contain a bar of the same width as that of the system diagram lines. The "closed" and "open" positions of the circuit breaker are indicated by "in line" and "across" positions respectively of the semaphore bar. In Fig. 3 are shown details of the equipment on the Moreton sub-station panel. In Fig. 4 is shown the supervisory remote control apparatus in the control room mounted at the rear of the switchboard sections, the relay sets being assembled in the form of self-contained jack units.

The supervisory control apparatus for each sub-station is mounted on a cubicle designed for erecting against the wall to conserve space. In Figs. 5–7 are shown three views of the Meols sub-station cubicle. The cabinets consist of two narrow width channel type racks placed back to back, the whole being enclosed with sheet iron, at the rear and having Plymax doors at the sides and front. As shown in Fig. 7, the rack on the right-hand side mounts the signalling apparatus on jack-in type relay bases, and the terminals for connecting to the circuit breakers. The spare positions on the bottom shelf accommodate a portable test set which can be readily jacked in for use. The relay bases are of three different types, and bases of the same type are interchangeable. Hence one spare set of relay bases can serve as stand-by equipment for all the sub-stations. The other rack, Fig. 6, mounts the photo-telemeter transmitters, one for current, and one for voltage readings and other photo-telemetering apparatus.

The control room desk, shown in Fig. 2, has two positions for two control engineers who sit facing the control switchboard. A telephone keyboard and a telephone instrument are provided for each control engineer, either of whom can reply to any incoming telephone call, or ring up any telephone instrument on the system by means of the keys. Connections between the control switchboard and the desk are made by means of multi-core cable laid in ducts in the floor. The wiring of the desk and the multi-core cable are terminated on jacks, thus enabling the desk to be moved for cleaning and maintenance purposes.

The method of operation is as follows:—Each circuit breaker is represented on the control panel by a key and lamp plaque set in the system diagram. The lamps, which are fitted with red and green caps, indicate the "closed" and "open" positions of the circuit breaker respectively. The key is used for selecting the circuit breaker for remote operation, and also to acknowledge any change in position of the circuit breaker that may have occurred automatically. To close the circuit breaker, the key is operated to the right in the position of the red lamp, labelled "close." When the circuit breaker has been selected, the red lamp is caused to flicker at about 300 per minute. The "operate" key which is situated at the bottom of the sub-station panel is then actuated momentarily, and causes the circuit breaker to close when the new position of the breaker is automatically signalled to the control room, whereupon the green lamp is extinguished, and the red lamp glows steadily. The key can then be restored to its neutral position. To open a circuit breaker a similar sequence of operations is carried out, but in this case the key would be operated to the left or "open" position.

If for any reason a circuit breaker trips, its new position is immediately signalled to the control room. The corresponding green lamp lights, and the red lamp flickers at about 40 per minute. The sub-station nameplate at the top of the panel affected is illuminated and a commen alarm bell is sounded. The change of position is acknowledged by the control engineer momentarily operating the circuit breaker key to the left or "open" position. This causes the red lamp and the illuminated nameplate to be extinguished, and also silences the alarm bell.

If a sub-station circuit breaker is closed by hand, the change of position is likewise indicated at the control room by the lighting of the associated red lamp, the flickering of the green lamp, the lighting up of the nameplate of that particular sub-station, and the sounding of the alarm bell. The control engineer acknowledges this change of position by momentarily actuating the circuit breaker key to the right or "close" position. On the various panels of the switchboard, a plunger key and a white lamp are appropriately located in the system diagram and associated with each meter reading. To select any desired meter reading such as total current or voltage of the bus bars or on any particular track feeder, the appropriate key is depressed, and the associated lamp lights when the selective operation has been completed. As the metering impulses from the various sub-stations are of different frequencies, a reading can be received from each sub-station concurrently without mutual interference. To disconnect any established metering selection, the particular key is simply restored to normal, whereupon the selective operation is automatically repeated to effect the necessary release of the latching relays that originally set up the connection at the sub-stations.

The telephone system includes various extension telephones in addition to the instrument at each sub-station, each sub-station group forming one

FIGS. 5 TO 7—MEOLS SUB-STATION CUBICLE

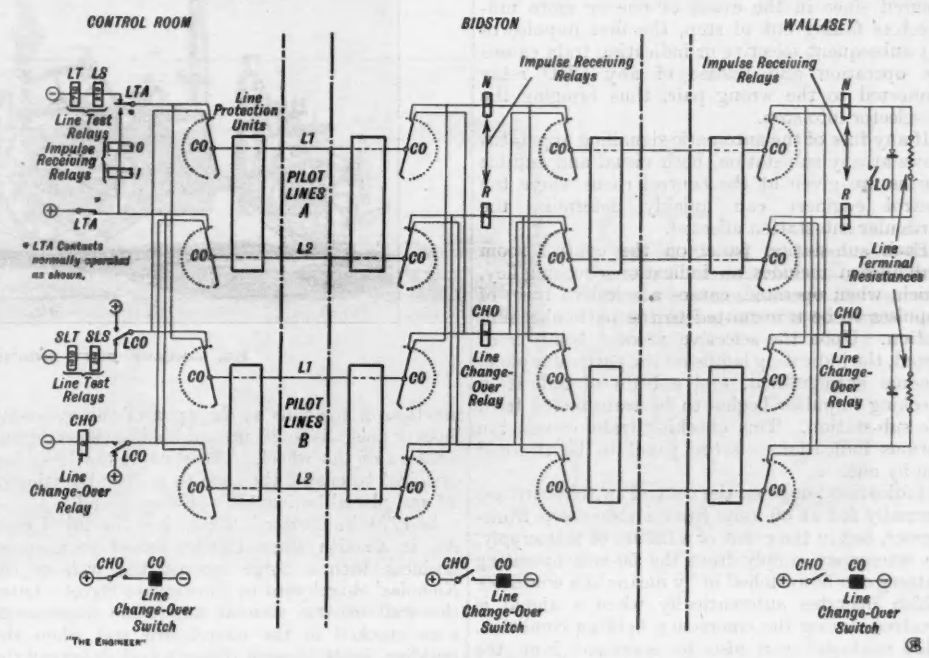


FIG. 8—DIAGRAM OF PILOT CHANGE-OVER ARRANGEMENTS

telephone circuit. A calling and answering key and a calling lamp are provided on the control desk for each telephone circuit and the simple act of lifting the hand-set on any of the sub-station or extension telephones causes the corresponding calling lamp to light and also rings the telephone bell on the desk, conversation being established by the control engineer actuating the key associated with the particular calling lamp. The telephone calling and answering key for each sub-station group has two operating positions, "up" and "down" Actuating to the "up" position causes the telephone instrument at the particular sub-station to be called, whilst the "down" position, which is labelled "extensions," enables any desired extension instrument to be called by dialling from the control desk, the act of dialling causing the desired telephone to be called by code ringing. The control engineers are also able to receive calls from and to dial directly to telephones on the Mersey railway private automatic exchange, whilst calls to and from the Liverpool Corporation private branch exchange can also be established.

Although two pairs of pilot wires are provided as already stated, only one pair is used at a time. The change-over arrangements are shown in Fig. 8. Each sub-station and control room is provided with a change-over uniselector CO. When all the uniselectors are standing on even numbered contacts, the impulse receiving relays and the impulse sending equipment are connected to the "A" pilot pair, and the CHO relays are connected to the "B" pilot pair. Normally a line testing current flows over the pilot pair not in use, but this current is insufficient to operate the CHO relays.

When it is desired to change over the pilot wires relay LCO at the control room is operated from a key. The operation of relay LCO reverses the direction of the current on the "B" pilot wire, and this causes the CHO relays at the control room and at each sub-station to operate, owing to the rectifier by-passing the terminal resistance. The operation of the CHO relays energises the driving magnets of the CO uniselectors and when the CHO relays are subsequently released, the uniselectors all make one step. This has the effect of transferring the impulse receiving relays and the impulse sending equipment from the "A" pair to the "B" pair, the change-over relays CHO also being transferred from the "B" pair to the "A" pair. Hence the arrangement demands that all the CO uniselectors remain in step. This essential synchronism is automatically ensured since in the event of one or more uniselectors falling out of step, the first impulse of any subsequent selective or indicating train causes the operation and release of any CHO relay connected to the wrong pair, thus bringing the uniselector into step.

If any fuse of the automatic signalling apparatus blows at any sub-station, both visual and audible alarms are given at the control room where the control engineer can quickly determine the particular sub-station affected.

Each sub-station panel on the control room switchboard includes an indication checking key, which, when operated, causes a selective train of impulses to be transmitted to the particular sub-station. Upon the selective process being completed, the indicating lamps on the particular panel become entinguished, and a train of indication checking impulses begins to be transmitted from the sub-station. This checking train causes the various indications on the panel to be restored one by one.

Indicating lamps on the control switchboard are normally fed at 50 volts from a step-down transformer, but in the event of a failure of this supply, an emergency supply from the 50-volt operating battery can be switched in by means of a contactor which operates automatically when a signal is received during the emergency lighting condition. This contactor can also be energised from the control desk.

Certain of the springs on the shelf jacks at the sub-stations are arranged to make contact when a relay set is withdrawn for inspection or maintenance purposes, and this enables the continuity of the pilot wires to the other sub-stations to be maintained during inspections or maintenance operations at an intermediate sub-station.

To facilitate the periodic routine testing of the sub-station apparatus, there is a portable test set which can be used at any sub-station by being simply jacked in position on the bottom shelf. The apparatus includes a hand-set for talking purposes and also various keys. When the "test commence" key is actuated "through" continuity of the pilot wires is established, thus permitting tests to be conducted on the particular sub-station without interfering with the functioning of the signalling apparatus of the other sub-stations. Virtually the test set is a collection of control room equipment in miniature, and enables the maintenance staff to apply a full series of tests for the purpose of proving the correct functioning of all sub-station equipment.

Normally a current of approximately 10 ma. is continually circulating over each pair of pilot wires, and maintains a relay operated in each case, but a disconnection in either pilot wire releases its relay and causes both visual and audible alarm signals to be given. The remote ends of each pair of pilot wires are terminated by a resistance, and normally carry the line test current and in the event of either pilot circuit being short circuited by a line fault, the line test current increases to about 40 ma. and operates a marginal relay at the control room to give alarm signals.

Since the Birkenhead North sub-station is in the same building as the control room the switchgear in this case is controlled directly over pilot wires to each circuit breaker and the metering is also direct.

(To be continued)

Some Early Burrell Engines

By RONALD H. CLARK, A.M.I. Mech. E.

MR. JAMES BOYDELL took out his patent for his "Endless Railway" in 1846, but later, in 1854, he took out a second patent which embodied a number of improvements over the first.

The principle of Boydell's "Endless Railway" consists of six flat plates or shoes fitted in their centres with a cycloidal slotted link or ancle, as it is called. A pin passes through the rim of the wheel and through the apex of the ancle so that as the wheel rotates a shoe is laid down on the ground; the wheel runs along it and as the wheel nears the end of the first shoe a second is laid down immediately in front of the first and so the cycle is repeated. The shoes work quite independently of each other and change their position as the wheel rotates; the shoes falling over by gravity just after passing the top of the wheel. As a shoe comes to the bottom of the wheel the latter is ready to run over it just as it has passed over the preceding shoe. A shoe, it will be appreciated, is quite stationary whilst the wheel passes over it. Thus the shoes form a complete and endless railway. A shoe cannot be lifted until the engine has passed over it and the engine does not pass on to the shoe in front until it is flat on the road. The sole function of the pins at the apex of the cycloidal links or ancles is to lift up and hold the shoe during rotation of the wheel. The slots in the links are cycloidal to enable the shoe to be lifted vertically off and placed horizontally on the ground.

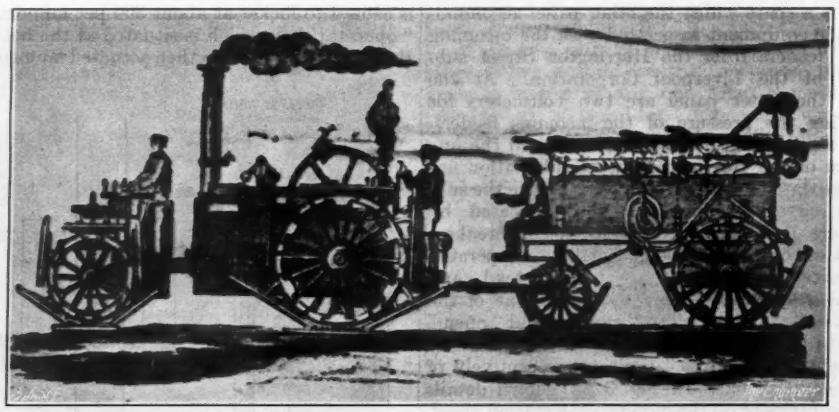


FIG. 1—HEAVY DUTY ENGINE WITH BOYDELL WHEELS—1856

In 1770, in Thetford, the ancient capital of East Anglia, a smith named Charles Burrell commenced business with a forge against the wall of St. Nicholas' churchyard in Minstergate Street. Later the wall became ruinous and some implements were stacked in the churchyard and when the building itself became disused and decaying the business absorbed (in later years) the whole of the site.

There were in point of fact three Charleses in the firm: Charles I; Charles II, who died in 1906; and lastly, Charles III, who deceased in 1929.

During the "reign" of Charles I a very fine silver cup was won at Holkham Sheep Show in 1803 for an improved drill machine for sowing oil cake manure with wheat and turnip seeds, &c. The author has handled this cup, preserved as a family heirloom, and a beautiful piece of work it is.

Later, in 1848, a year after the birth of Charles III, the firm produced the first combined threshing and dressing machine that was ever offered to the public. It was exhibited at the Royal Agricultural Show at York in that year and it gained the Society's prize medal.

They commenced about this time the manufacture of ordinary portable engines (of which more anon), single flour mills which ground and dressed flour for domestic use at one operation, portable flour mills on a four-wheeled chassis, a registered machine for making gates and hurdles, gorse cutting and bruising machines, and horizontal engines.

It was not surprising then that in 1856 Burrells should make the first engine embodying Mr. Boydell's "Endless Railway," and a reproduction of this is shown in Fig. 1. This illustration, by the way, is taken from Burrell's first catalogue of 1860, a single sheet measuring 26¾in. by 17in., of which there are now few copies extant. Note that the front part of the engine rested on an entirely separate forecarriage also equipped with Boydell's wheels, by means of which the outfit was steered. The engine was rated at 12 N.H.P. and had two high-pressure cylinders, 7½in. bore by 12in. stroke, which were mounted on top of the locomotive type boiler, the crankshaft pinion meshing with a large spur wheel bolted directly on the rim of the Boydell driving wheel. It was in modern parlance a two-shaft engine. The engine is shown to be pulling a trailer laden with four multi-furrow ploughs for use by direct pulling by the engine. The "gaffer" appears to be directing operations from the front of the trailer. The trailer was described in the catalogue already referred to as "Travelling Tank to Contain One Day's Supply of Water and Coals." Of the engine Mr. Burrell says: "This invention is of national importance, as it removes the only difficulty hitherto experienced in making Steam Traction profitably available, both upon common roads and for agricultural purposes. The working and the power of the Traction Engine and Endless Railway on common roads have been fully and satisfactorily tested at several places, and the following important results obtained—viz., that, on the best ordinary roads, the heaviest loads can be drawn with greater economy than by horse-power; and that, in ascending or descending the steepest hills, or in passing over soft and marshy ground, *where no roads exist*, this engine and railway have been found to overcome difficulties which no available amount of horse-power could possibly accomplish. For Agricultural Operations, the experiments have proved, if possible, even more satisfactory, inas-

much as land ploughed at different places, in the presence of a very large number of practical agriculturalists, has been pronounced by them to have been better done than by horses, while the saving of cost has been variously estimated from 40 to 70 per cent., according to the description of the work done, and possessing this great advantage—that, in ploughing on soft or wet ground, *the Endless Railway and Engine do infinitely less harm to the land than the horses feet in drawing the Ploughs.* Ploughing to a depth almost impossible to accomplish by Horses has been both efficiently and economically performed by means of this Invention. The Traction Engine, when fitted to the Endless Railway, possesses all the advantages of the Portable or Stationary Engine, with the great additional one, that it can transport itself where required, without the aid of horses, and draw with it Thrashing Machines, Corn Mills, Scutching Mills, Ploughs, or any other implements intended to be worked by it. Another very important feature of it is, that the Engine passing so smoothly over the Endless Railway, the machinery is liable to far less injury and wear and tear than a Portable Engine drawn on ordinary wheels. As a Feeder to the Goods Traffic of Railways, by superseding the necessity of short and expensive Branch Lines, especially in thinly populated districts, the advantages of the 'Traction Engine and Endless Railway' can scarcely be overrated." In view of the present-day dislocation of road traffic due to reliance on imported fuel, Mr. Burrell's words on the steam road engine as being of "national importance" seem still to be very apt.

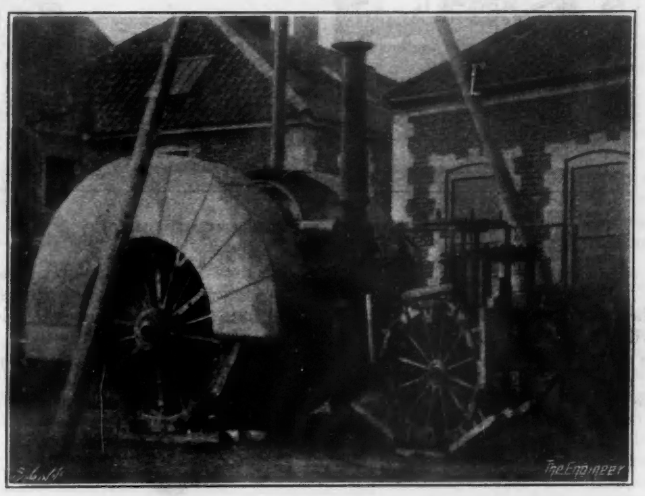


FIG. 2—ONE OF THE FIRST THREE BOYDELL ENGINES—1856

FIG. 3—PLOUGHING ENGINE—1868

Fig. 2 is a reproduction of an actual photograph of one of the first three of Burrell's Boydell engines taken whilst it was in their yard for repairs. The driving wheels are covered with riveted sheet metal covers. The steerage on the fore carriage is effected by a horizontal hand wheel swivelling the axle by single reduction spur gearing.

During the next year, 1857, a number of modifications were made, as seen in the engine in Fig. 4, notably heavier ribbed cylinders, very ornamental and fluted safety valve casing, the addition of an intermediate shaft, making it now a three-shaft engine. A new design of steerage carriage is employed comprising what one might term a "bowsprit" in front attached to the axle, the end of the bowsprit being pulled from side to side by chains operated from the steering wheel mechanism. The tall T erection was a direction indicator, *i.e.*, the T rotated as the axle turned, the top of the T giving the direction of the steerage carriage. Note that the engine is pulling by direct traction four patent Burrell ploughs, each cutting two furrows.

In Fig. 5 we have yet another modification of the Boydell engine, where the steerage carriage is built in one with the extended main frames of the engine. Boydell steering wheels have given place to plain iron-tyred wood wheels, steered by bevel reduction gearing on to the track rod. The single cylinder is placed well forward of the chimney and on the near top side of the boiler. Two pinions on two shafts are shown, the after one of these two pinions connecting the crankshaft and the fly-wheel shaft. The connecting-rod pinion could be shifted out of gear to allow the fly-wheel shaft to be used when it was desired to belt drive from the fly-wheel. The water tanks are shown, complete with panels, beneath the boiler.

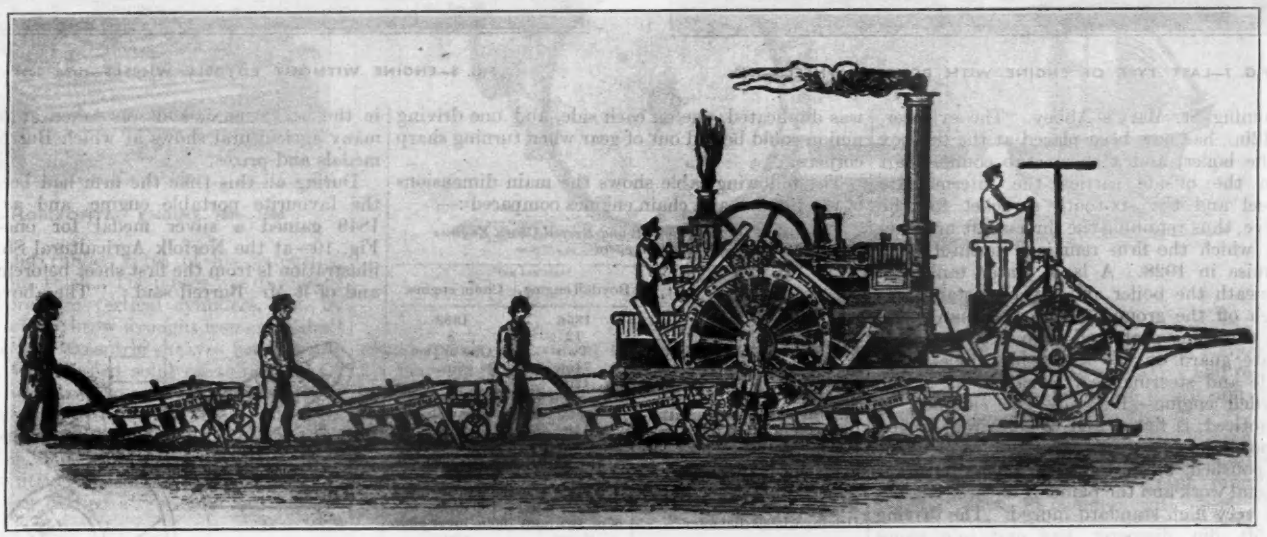


FIG. 4—TRACTION ENGINE IN USE FOR PLOUGHING—1857

By the year 1858 Mr. Burrell had taken out a patent for an improved method of attaching the shoes to the wheels where Boydell's wheels were used, and later that year brought out the engine depicted in Fig. 6. Disc wheels are now employed, the shoes being attached on alternate sides of the ribbing of the discs. The two-ribbed cylinder, 9in. by 12in. stroke, has again had a move, this time to the right-hand side of the chimney base. The fly-wheel is now mounted on the crankshaft in what is now the familiar place, and a countershaft included between the crankshaft and the rear wheels, so we again have a three-shaft engine. A large water tank is fitted beneath the boiler, the latter being lagged with strip wood and varnished. Perhaps the most interesting feature of this type of engine was the steerage by a horse in front. The reason was that at this time traction engines were very uncommon and frightening for horses. Horses were therefore less likely to shy at an engine headed by one of their kind.

Fig. 6 is taken from the same sheet as Fig. 1, and of it Mr. Burrell says: "This engine moves itself, and is capable of drawing a Thrashing Machine *over rough roads, or where no roads exist.*" Many buyers were obviously satisfied with the working of the Boydell wheels as evidenced by the following testimonial from a Mr. William Goldsmith, of Ixworth, dated April 29th, 1860:—"The Traction Engine fitted with Boydell's Endless Railway, which you supplied me with in January, 1858, has been in constant use, propelling from one farm to another, drawing the Thrashing Machine; no accident has ever happened from its having frightened horses on the road, and there is no complaint made by anyone in the neighbourhood where it is used. It has travelled from 12 to 20 miles in the week since I have had it." So in this case the horse in front was doing his bit!

It is obvious that the steerage systems hitherto adopted, viz., fore carriages and horses, were somewhat cumbersome and inefficient, and in the next and last type of Boydell engine to be marketed in 1860, the fore carriage and horse are dispensed with and the simple wagon axle attached, operated by a large hand wheel and reduction gearing shown on the engine in Fig. 7. The steersman stood with his back to the smoke-box, which should have been an asset in cold weather! Two cylinders are again employed set just aft of the chimney. A nest of four excentrics was placed between the cranks, the crankshaft pinion meshing direct with the driving wheel gear, making a two-shaft engine. A fine polished brass dome is fitted over the safety valve and a Watt type governor included for constant speed running when threshing.

Very heavy loads were tackled by Burrell-Boydell engines, and in September, 1857, a load

of 43 tons 18 cwt. was drawn by a Boydell engine from Bury St. Edmunds to Woolwich Arsenal at an average speed of 3·1 m.p.h. over roads which, judged by present-day standards, could be described as appalling. Several such journeys revealed that the overall cost was 2d. per ton per mile; the corresponding cost by horses then would have been 6d. per ton per mile.

Apparently maintenance costs of the Boydell wheels increased as their age increased, and by 1868 a new type of engine was designed and made at Thetford, and I am able to reproduce in Fig. 8 an actual photograph of the first one, taken in a field adjoining St. Mary's Abbey. The cylinder, 9in. by 12in., has now been placed at the fire-box end of the boiler, and a short stub countershaft fitted on the offside carries the intermediate gear wheel and the six-tooth sprocket for the chain drive, thus retaining the three-shaft arrangement to which the firm remained faithful until their demise in 1928. A large water tank was fitted beneath the boiler and the man-stand was quite high off the ground. The steersman stood in front, this time protected from excessive heat by a plate guard on the smoke-box door. The front axle and steering gear remained as in the last Boydell engine—Fig. 7. The chimney, it will be noticed, is fluted and of cast iron, hinged as per portable engine practice and resplendent with a polished brass top cap. The finish of bright metal work and the painting of these engines was of a very high standard indeed. The driving wheels, 5ft. 6in. diameter, had cast iron naves and plain rims and wrought iron spokes. Later, the now familiar diagonal plates were added to form the tread. One outstanding feature of these engines was that they were spring mounted, the scheme being outlined in the diagram shown in Fig. 9. The rear axle-boxes were permitted to slide up and down in slots in the frames at right angles to the centre line of the two chain wheels, the damping being effected by the volute spring in each slot. The amount of movement allowed was from ½in. to ¾in., the variation in chain tension being accommodated in the initial slackness. An old driver who remembered these engines in his youth told me the springing was quite effective and eliminated a great amount of jarring on poor roads. About 150 of these engines were made and sold by 1876.

Mr. Burrell, in his 1869 "leaflet" (size 11¼in. by 8¾in.), invites particular attention to the improvements he has made in engines of this class, and goes on to enumerate the refinements as "Link-Motion Reversing Gear; Steerage Wheel and Wrought Iron Tank, holding a supply of water for six miles. A Lock-up Safety Valve is applied." The last item suggests a little grim humour!

These engines were supplied with one cylinder and one driving chain, one cylinder and two driving chains, two cylinders and one driving chain, or two cylinders and two driving chains. Where two chains were specified, the stub countershaft was duplicated, one on each side, and one driving pinion could be slid out of gear when turning sharp corners.

The following table shows the main dimensions of the Boydell and chain engines compared:—

TABLE I.—*Burrell-Boydell and Burrell Chain Engines Compared*

Details.	Boydell engine.	Chain engine.
Date	1856	1868
N.H.P.	12	8
Number of cylinders	Two	One or two
Bore of cylinders	7½in.	9in.
Stroke	12in.	12in.
Grate area	5·5 square feet	4·2 square feet
Number of tubes	Seventy-one	Thirty-three
Diameter of tubes	1¾in.	2¼in.
Water heating surface per N.H.P.	22·8 square feet	18·5 square feet
Water heating surface per square foot of grate area	49·0 square feet	35·0 square feet
Average steam pressure	100 lb./sq. in.	100 lb./sq. in.
Driving wheels diameter	66in. (without shoes)	66in. (over plain rims)
Driving wheels width	16in. over shoes 6½in. over tyre	14in.
Ratio of gears, fast	8 to 1	12 to 1
Ratio of gears, slow	17 to 1	18 to 1
Advance of engine per foot of piston travel, fast	1·070ft.	0·720ft.
Ditto, slow	0·5ft.	0·480ft.
Capacity of water tanks	315 gallons	150 gallons
Capacity of coal bunkers	10 cwt.	8 cwt.
Weight of engine empty	9 tons 0 cwt.	7 tons 10 cwt.
Ditto in working order	11 tons 10 cwt.	9 tons 0 cwt.
Weight on driving wheels	8 tons 0 cwt.	6 tons 10 cwt.
Ditto on leading wheels	3 tons 10 cwt.	2 tons 10 cwt.
Length overall	17ft.	16ft.
Width overall	—	6ft. 4in.
Remarks	For heavy haulage	For agricultural purposes

The next few years, 1868 to 1876, were years of great activity at Thetford, and by about 1870 Burrells were manufacturing under licence from Fowlers of Leeds the latter's patent steam ploughing engine, and I am able to reproduce an actual photograph of one in Fig. 3. It shows a 12 N.H.P. single-cylinder engine with a patent coil gearing arranged so that the rope can take any angle the direction of the furrow may require without putting any pressure on the coiling gear. The road gear is arranged so that the engine can travel at two different speeds. Note particularly that the cylinder is steam jacketed by housing it in a steam dome. The front half of the boiler is again selected for the cylinder, and from now onwards, after many positions, this was its last resting place, where it was always put in later designs. The photograph shows marquees and another engine in the background, and was taken at one of the many agricultural shows at which Burrells gained medals and prizes.

During all this time the firm had been making the favourite portable engine, and as early as 1849 gained a silver medal for one—seen in Fig. 10—at the Norfolk Agricultural Show. This illustration is from the first sheet beforementioned, and of it Mr. Burrell said: "The above Engines are fitted with a Hot Water Cistern, and Registered Apparatus for pumping hot and cold water, by which a saving of 20 per cent. in fuel is effected. They are fitted with workmanship of the first class. The whole of the Fire Boxes *are warranted of Low Moor Iron*, and all manufactured upon the premises to ensure the best of workmanship and durability." This would be a very early example of feed-water heating. The design of the connecting-rod

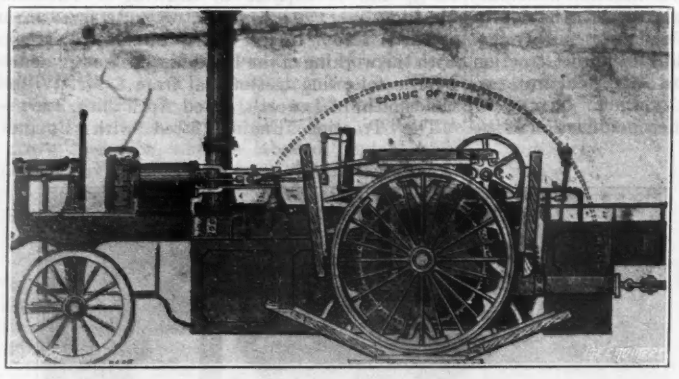


FIG. 5—ENGINE WITH PLAIN WHEEL STEERING

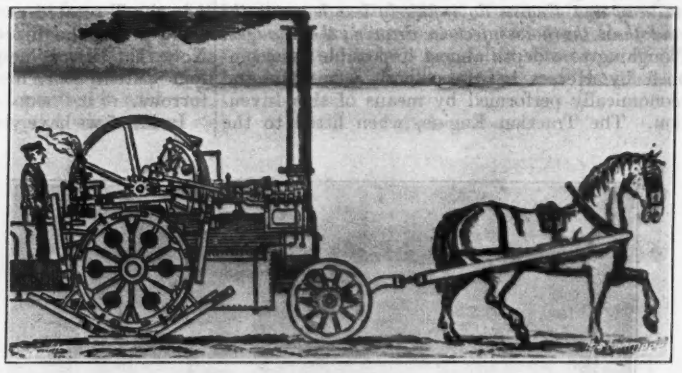


FIG. 6—HORSE STEERED ENGINED—1858

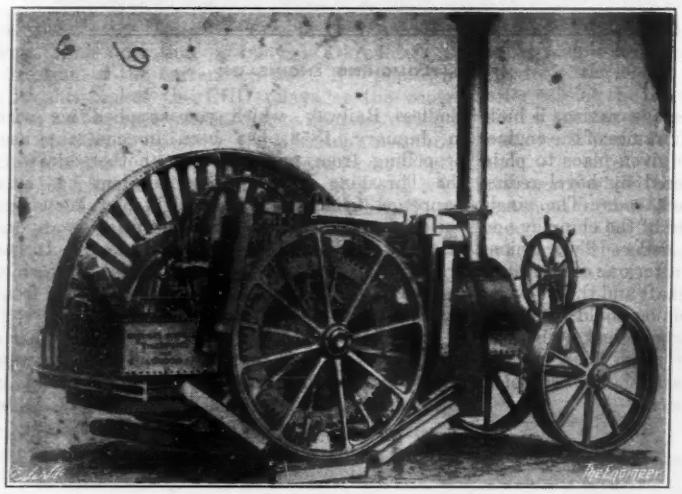


FIG. 7—LAST TYPE OF ENGINE WITH BOYDELL WHEELS—1869

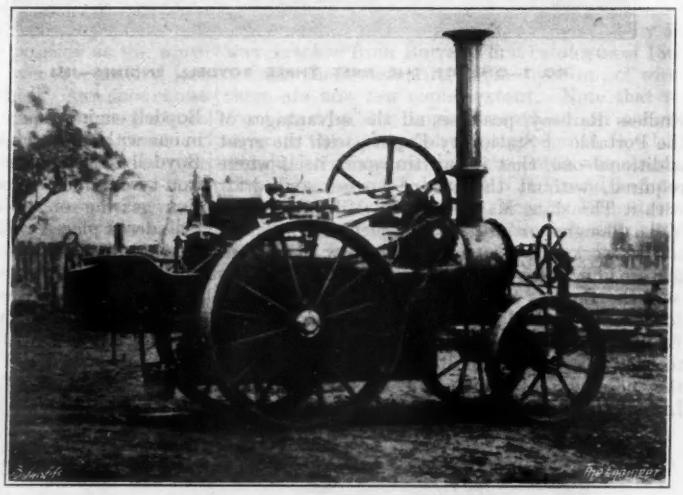


FIG. 8—ENGINE WITHOUT BOYDELL WHEELS—circa 1868

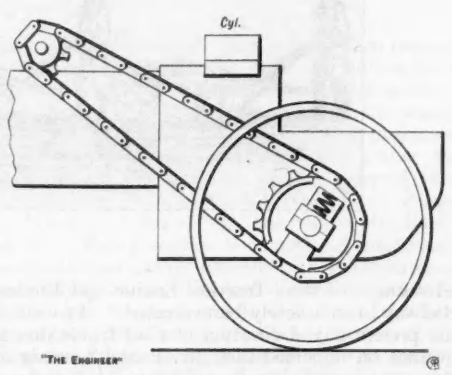


FIG. 9—SPRING MOUNTING

is very typical of the period and the crankshaft bearing brackets and heavily ribbed cylinder made a very sturdy and lasting job. The engine illustrated was of 8 N.H.P., but the exact cylinder dimensions are lacking. Very many of these engines were sold, both in this country and on the Continent.

A standard design of horizontal engine ranging from 6 to 20 N.H.P. was made from 1850 to 1880, and a typical example is included in Fig. 11. The cylinder was lagged with mahogany confined by

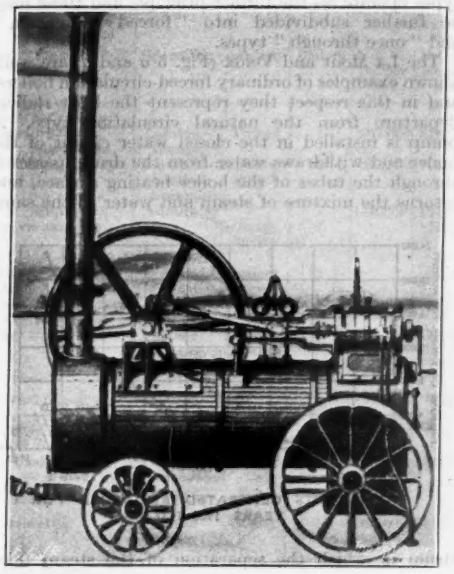


FIG. 10—PORTABLE ENGINE—1849

polished brass bands. Steam was supplied from a Cornish boiler made in the boiler shop, which catered for boiler trade extra to traction engine work, and Burrells undertook the complete installation of plants of this type. Extra fittings to the engine were a variable expansion valve, an improved water heater, and link motion reversing gear.

Experimenting was now going ahead as much as ever in the Thetford drawing-office, and in 1871 the three-wheeled engine seen in Fig. 15 was evolved, embodying Thompson's vertical "coffee

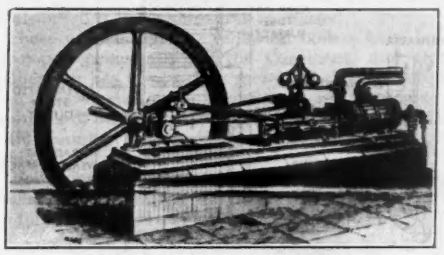


FIG. 11—HORIZONTAL ENGINE 1850—1880

pot" boiler and rubber tyres of his patenting, 15in. wide by 5in. thick. The power was developed by two high-pressure vertical cylinders, 6in. by 10in., driving a two-throw wrought iron crankshaft containing the four excentric sheaves between the throws which were forged solid on the shaft. A sliding pinion was fixed to each end of the crankshaft which meshed with a spur wheel bolted on to the inside of the driving wheels. This was the high-speed gear, but provision was made for a lower speed by fitting a second motion shaft across the engine which carried at its ends two pinions which could be slid into mesh for the slow speed with the spur gear on the driving wheels. In Fig. 15 the two levers can be seen by which these gear changes were carried out, and it was possible by their means to throw one driving road wheel out of gear when negotiating a very sharp corner. The Thompson rubber tyre was patented in 1849. Three such engines were made by Burrells for Turkey in 1871.

But the vertical coffee pot boiler gave a great amount of trouble in service, and, wisely, Burrells dropped it, and produced the high-speed engine seen in Fig. 12. This also was for the Turkish Government, and when on test around Thetford easily toured at 20–21 m.p.h., an accomplishment of which the makers were very proud. Here the cylinders, 7½in. bore by 10in. stroke, are placed over the fire-box and the internal gearing to the road wheels is dispensed with, the power being transmitted by straight spur gearing. The rear ends of the cylinders and all motion parts are neatly enclosed. The driving wheels were 6ft. diameter and rubber covered, as were the 4ft. diameter leading wheels. Steering was effected by the worm and worm wheel seen in the illustration. Being rubber mounted, they ran very quietly and were very satisfactory, especially as they had a two-speed gear.

Later, in 1871, a similar engine was commenced and finished early in 1872. This engine was ordered by the Government of Crete for working passenger traffic, the passengers being accommodated in a "bus," also made in the works. When finished the test consisted of loading the bus to the uttermost with individuals of all shapes and sizes, and touring round Thetford. Fortunately, in Fig. 13 I am able to reproduce the photograph taken during this historic incident, which gives some idea of the severity of the "test load." Standing in the centre of the group with walking stick is Mr. Robert Burrell, brother of Charles H. The individual on the extreme left of the picture is the boy with the red flag. When indulging in

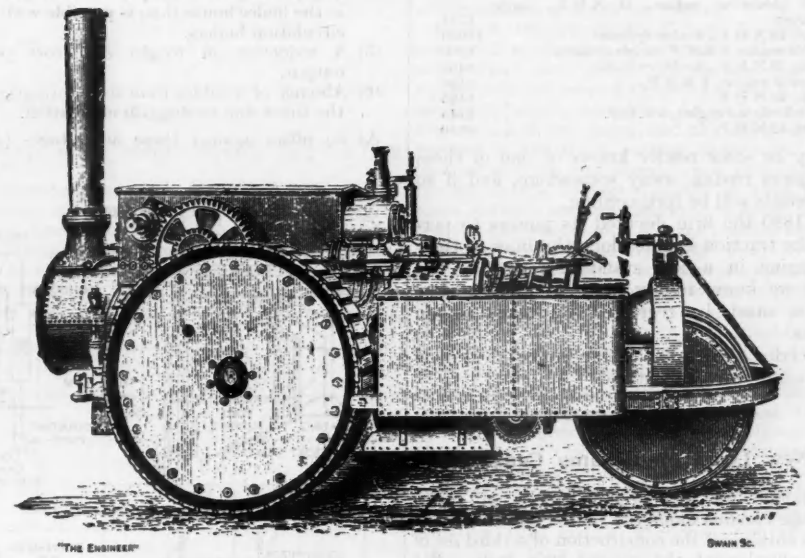


FIG. 12—HIGH-SPEED ENGINE—1871

illegal speeds he rode on the footplate, resuming his place in front when a representative of the law was observed in the distance. In this engine the driving wheels were 5ft. diameter and the leading 3ft. 6in. diameter. The two high-pressure cylinders, 6in. by 10in., were placed at the funnel end and took steam at 130 lb. per square inch. An American type spark catcher was fitted to the funnel and a canopy over the engine. The rating was 12 N.H.P. and the weight in working order was 16½ tons. The famous test load was estimated at 37 tons gross, which the engine pulled up the 1 in 18 hill at Croxton at 5 m.p.h. Its touring speed was 9 m.p.h. with a maximum of 12 m.p.h.

Side by side with the engine for Crete another was made in St. Nicholas' works for the Govern-

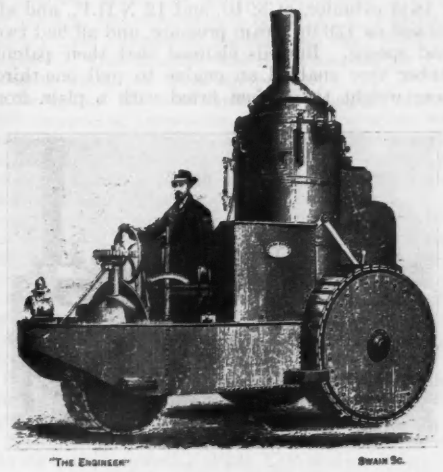


FIG. 15—THREE-WHEELED ENGINE—1871

ment of Russia, slightly smaller, being rated at 8 N.H.P. This was complete with a mail van and a photograph of the complete unit is seen in Fig. 14. The driving wheels are equipped with the Burrell patent tyre, consisting of a rubber tread protected by thirty-five to forty steel armour plates which just touched each other outside the rubber tyre and were tapered at their ends and were each bent over at each end so as to clip over the iron rim of the wheel and on both sides of it. They were very effective and resilient, and Fig. 15 shows clearly the depression of the tyre against the ground when loaded.

The success of this type of engine for fast road work was very marked, and they became standardised in the form shown in the photograph reproduced in Fig. 16, taken, in common with Figs. 13 and

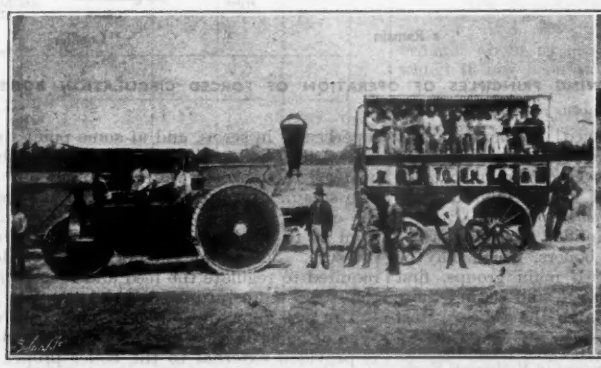


FIG. 13—HIGH-SPEED ENGINE FOR CRETE WITH TEST LOAD

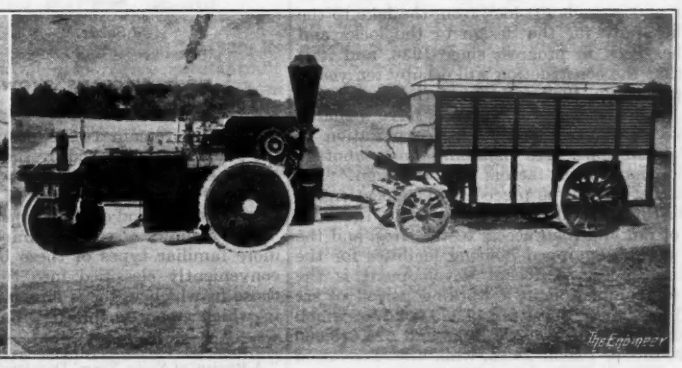


FIG. 14—HIGH-SPEED ENGINE FOR RUSSIA DRAWING MAIL VAN

14, on the road to Brandon. Mr. Robert Burrell is sitting in charge and the bewiskered gentleman behind is the machine shop foreman. Here, again, the metallic and paint finish was superb, all gearing enclosed as effectively as possible, and the cylinder or cylinders retained in the position familiar to-day. A market was found for them, not only to foreign Governments, but to haulage and threshing contractors and many farmers. They were made in three sizes, single or twin cylinder, of 8, 10, and 12 N.H.P., and all worked on 120 lb. steam pressure, and all had two road speeds. Burrells claimed that their patent rubber tyre enabled an engine to pull one-third more weight than when fitted with a plain iron

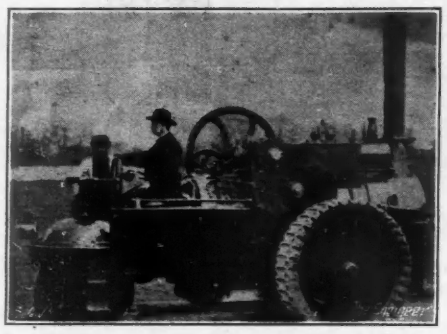


FIG. 16—HIGH-SPEED ENGINE—1878

tread. The front wheel, when not rubber tyred, had the axle spring mounted. The makers claimed that they could be turned in their own length.

Prices always make interesting reading, and the following columns show the list prices for various Burrell engines compared, the period covered being from 1860 to 1880 :—

TABLE II.—*List Prices of Burrell Engines from* 1860 *to* 1880

Type of engine.	List price.
Boydell engine, 10 N.H.P.	£750
Chain engine, 8 N.H.P.	£465
Fowler ploughing engine, 14 N.H.P., single cylinder	£715
Ditto, 20 N.H.P., double cylinder	£1050
Portable engine, 6 N.H.P., single cylinder	£200
Ditto, 20 N.H.P., double cylinder	£495
Horizontal engine, 6 N.H.P.	£180
Ditto, 20 N.H.P.	£495
Three-wheel road engine, 6 N.H.P.	£445
Ditto, 12 N.H.P.	£660

It may be some reader knows of one of these early engines rusting away somewhere, and if so I hope details will be forthcoming.

After 1880 the firm devoted its powers to perfecting the traction engine along the lines of their chain engine in a few standard forms to the machine we know to-day, and its present slow extinction must be regretted by many steam adherents.

Thus ended the period of experimental designs of early engines from Thetford.

New Locks on Panama Canal

To provide for estimated increases in traffic through the Panama Canal the United States Government has authorised the construction of a third set of locks to supplement the present twin locks. For military reasons, and as a precaution against possible future air attacks, the new locks are to be at some distance from the others, and situated on by-pass channels diverging from the existing canal. The lock chambers will be 1200ft. long and 135ft. wide, with 45ft. depth of water on the sills. Their diversion channels will have a minimum width of 300ft. and minimum depth of 40ft. of water. At the Atlantic end there will be a flight of three locks, half a mile from the present Gatun locks, and provision is made for a second parallel flight in the distant future. The locks at the Pacific end will be about 1500ft. from the present set, with a two-stage flight into the Miraflores Lake and a single lift lock from the lake to the canal. The study for the design of the locks and channels has been in progress since 1936, and it is expected that the construction will occupy ten years, with completion in 1950. Much of the foundation work will be in rock, and the studies have included seismic investigations and core-drill exploration of geological conditions. Air bombing and sabotage in operation have been factors in the design. The main construction will be preceded by relocations of the trans-isthmian railway and highway, the construction of rail and road access to the sites, and the provision of well equipped housing facilities for the construction forces. A recent development is the planning for completion in a working period of six years. The estimated cost is £55,355,000 ; of which £18,553,000 is for the Atlantic locks and £26,648,000 for the two sets of Pacific locks, while the excavation of the new connecting channels will cost about £10,154,000.

Mechanical Engineering for Power Stations*

By Sir LEONARD PEARCE, D.Sc., M.I. Mech. E.

No. II

(*Continued from page* 86, *Jan.* 26*th*)

FORCED CIRCULATION BOILERS

THE adoption of higher operating steam pressures has undoubtedly done much to bring the forced circulation boiler to the forefront, due to the fact that as the pressure is increased the relative densities of steam and water at saturation temperature (upon which thermo-syphonic circulation, or more familiarly, "natural circulation," depends) alter so considerably. This is amply illustrated by Table II.

TABLE II.—*Variation in Density of Saturated Steam and Water at Various Pressures*

Steam pressure, lb. per sq. in. abs.	Density of saturated steam, lb. per cu. ft.	Density of water at saturation temperature, lb. per cu. ft.
200	0·437	54·4
350	0·753	52·3
600	1·29	49·8
1200	2·77	43·6
1500	3·61	41·8
2000	5·3	39·2

Amongst other advantages claimed for the forced circulation principle are :—

(1) The ability to use tubes of much smaller bore and hence reduced thickness for higher operating pressures.
(2) The reduction in number and, in certain instances, the entire elimination of drums.
(3) The freedom to dispose the heating surface to the greatest advantage with respect to heat transfer.
(4) Resulting from these three points, the ability to obtain a greater evaporation in a given space in the boiler house than is possible with natural circulation boilers.
(5) A reduction in weight and cost per unit output.
(6) Absence of troubles from scale formation inside the tubes due to sluggish circulation.

As an offset against these advantages (some of which still remain to be proved) is the fact that the plant is complicated by the inclusion of pumping equipment, which absorbs power continuously, and to guard against the failure of which elaborate protective devices and controls must be provided.

Fig. 5 shows a series of simplified diagrams of the more familiar types of these boilers, which may be conveniently classified into two main groups, first those in which water is circulated, and second those in which steam is forced through the tubes. Most types operate on the former principle and these may be further subdivided into "forced circulation" and "once through" types.

The La Mont and Velox (Fig. 5 *a* and *b*) are well-known examples of ordinary forced-circulation boilers, and in this respect they represent the least radical departure from the natural circulation type. A pump is installed in the closed water circuit of the boiler and withdraws water from the drum, passes it through the tubes of the boiler heating surface, and returns the mixture of steam and water to the same drum in which the separation of the steam takes place.

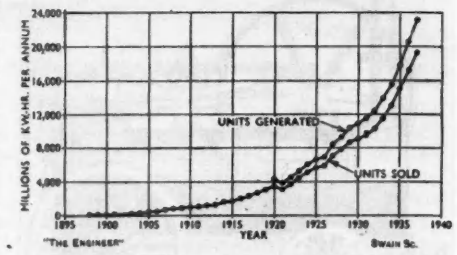


FIG. 6—UNITS GENERATED AND SOLD FOR YEARS 1900-1937

The quantity of water circulated is about six to eight times the maximum continuous rating with the La Mont boiler and about ten to twenty times with the Velox, this quantity remaining constant irrespective of the loading on the boiler.

The "once through" principle is used in the Benson, Sulzer, and Ramsin boilers (Fig. 5 *c*, *d*, and *e*). In this type the main boiler feed pump itself constitutes the circulating agent and the feed to the boiler is regulated exactly by the steam output required, the distinguishing feature being the absence of any drums. The continuous circuit in the boiler is analagous to an economiser, boiler, and superheater in series, and at some point towards the end of the "boiler" and the beginning of the "superheater" sections the water is completely converted into steam. In order to overcome the resistance of the circuit the pressure at the inlet requires to be from 20 to 40 per cent. in excess of the final steam pressure. Somewhat elaborate control devices are required to regulate the feed and fuel quantities and the steam temperatures, &c.

The well-known example of the steam circulation type of boiler is the Loeffler, in which a steam drum is provided external to the boiler proper (Fig. 5 *f*). A pump withdraws saturated steam from this drum and discharges it through tubes which constitute

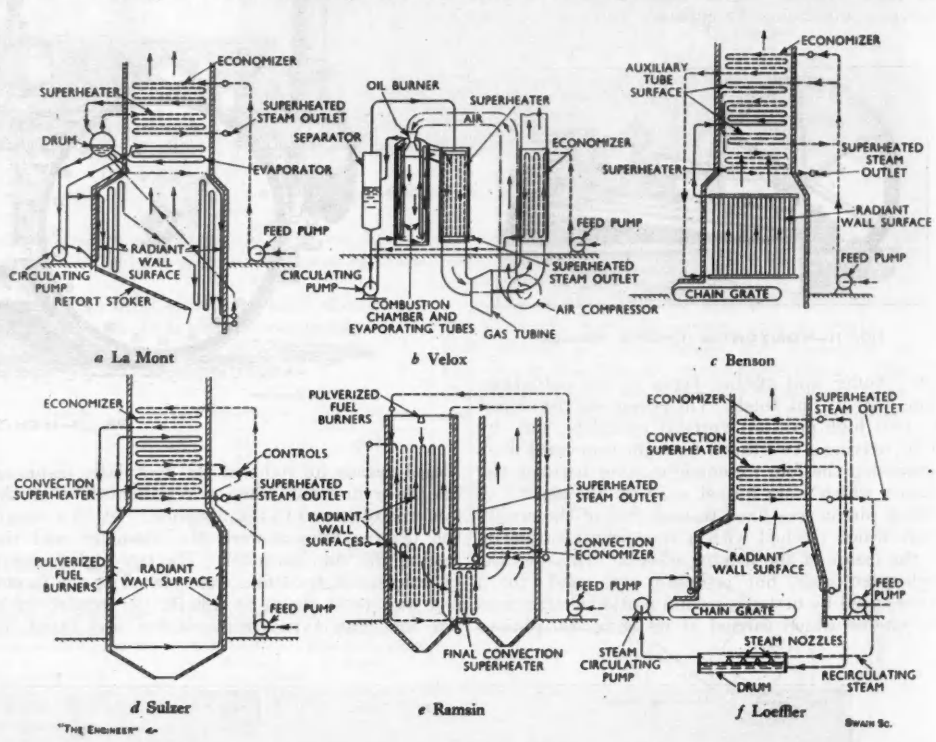


FIG. 5—DIAGRAMS SHOWING PRINCIPLES OF OPERATION OF FORCED CIRCULATION BOILERS

* From the Twenty-Sixth Thomas Hawksley Lecture, entitled "A Review of Forty Years' Development in Mechanical Engineering Plant for Power Stations," delivered before the Institution of Mechanical Engineers on January 19th, 1940.

radiant and convection superheaters, the amount circulated being about three times the actual steam output of the boiler. One-third of the steam at the outlet of the superheaters is taken away to the turbine or other point at which the steam is required, and the remaining two-thirds are discharged back to the steam drum in which it gives up its heat to the feed water therein, to produce saturated steam.

As distinct from the water circulation boilers in which the pump output remains constant irrespective of load, the steam pump of the Loeffler boiler is varied in output according to the load on the boiler. This type of boiler can only be used economically in the steam pressure range from 1700 to 2000 lb. per square inch, due to the excessive power which would be absorbed if lower pressures were used.

These various forced circulation boilers have been developed principally on the Continent, and their application has been rather more in industrial plants than in power stations. However, there are now quite a number of boilers in operation or under construction in this country, as may be seen from the list given in Table III.

[Following a brief section devoted to Flue Gas Washing Plants the lecturer drew to a conclusion with the following remarks.]

Output, Maximum Demand, and Installed Plant Capacity

It appears fitting to conclude this lecture by a reference to the general growth in the demand for electricity over the period considered.

In Fig. 6 are shown the annual figures for the units of electricity sold by authorised undertakers in Great Britain since the beginning of this century and for the units generated since 1920. The latter shows an increase of no less than 437 per cent. in seventeen years.

In the United States the total annual generation of electricity has increased from 43,555 million units in 1920 to 120,996 million units in 1937, corresponding to an increase of 178 per cent. over the same seventeen-year period. It is estimated that world production has increased from 310,000 million units per annum in 1929 to 470,000 million units in 1937, an increase of over 50 per cent. in only eight years.

This increase in consumption has, of course, been accompanied by a corresponding growth in instantaneous loads to be carried, and in Fig. 7 are shown the aggregate maximum demands on authorised undertakings in this country between the years 1909 and 1937.

The generating capacities of stations have had to be increased to cope with these loads, and Fig. 8 shows the total installed capacity of all generating stations owned by authorised undertakers in this country, and the aggregate of the maximum demands on those stations. These curves are interesting in that they illustrate the effect of interconnection brought about by establishing the Grid in 1930, by which it has been possible to reduce substantially the amount of spare plant which would have been necessary if each undertaking had to carry sufficient plant to provide for all local emergencies.

These three diagrams, by displaying the rapid increase in consumption of electricity, explain in large measure why such great progress has been made in the size, design, and construction of the plant involved.

Table III—*Special Forced Circulation Type Boilers Installed or on Order in Great Britain.*

Station	Operating company	No. of boilers	Capacity* N.E.R., lb. per hr.	Capacity* M.C.R., lb. per hr.	Steam pressure, lb. per sq. in.	Steam temperature, deg. F.	Feed temperature deg. F.	Air temperature, deg. F.	Method of firing	Notes.
La Mont Boilers										
Deptford West	London Power Company	1	280,000	350,000	350	780–850	240	100	Retort stoker	
Willesden (Taylors Lane)	North Metropolitan Electric Power Company	3	120,000	150,000	1400	960	350–360	60	Chain grate stoker	
H.M. Ship	Admiralty	1	110,000	125,000	300	640	211	80	Oil	
Wolverhampton	West Midlands Joint Electricity Authority	4		120,000	400	850	315	90	Chain grate stoker	
British Dyestuffs (Huddersfield)	Imperial Chemical Industries	2		75,000	650	788	300	70	Chain grate stoker	
Wallerscote Works (Northwich)	Imperial Chemical Industries	1	60,000	75,000	800	777	356	100	Chain grate stoker	
West Bank	Castner Kellner Alkali Company (Imperial Chemical Industries)	2	60,000	75,000	625	914	315–325	80	Chain grate stoker	
Works, Glasgow	G. and J. Weir	1	40,000	50,000	1000	850	216	60	Chain grate stoker	
Sulzer Boilers										
Bargoed Colliery	Powell Duffryn Associated Collieries	2	110,000	130,000	1565	770	445		Pulverised fuel	Also reheating at 366 lb. per sq. in. to 770 deg. Fah.
Warrington	Thames Board Mills	3	65,000	81,250	1400	800	300		Chain grate stoker	
Loeffler Boilers										
Brimsdown "A"	North Metropolitan Electric Power Company	2	175,000	210,000	1900–2000	932–940	355–362		Chain grate stoker	Also reheating at 200 lb. per sq. in. to 810 deg. Fah.
Brimsdown "B"	North Metropolitan Electric Power Company	2	200,000	250,000	1900–2000	932–940	355–362		Chain grate stoker	Also reheating at 315 lb. per sq. in. to 840 deg. Fah.
Velox Boilers										
Haslar Experimental Station	Admiralty	1		112,000	300	630	150–250	77	Oil	

* N.E.R., Normal evaporation rating. M.C.R., Maximum continuous rating.

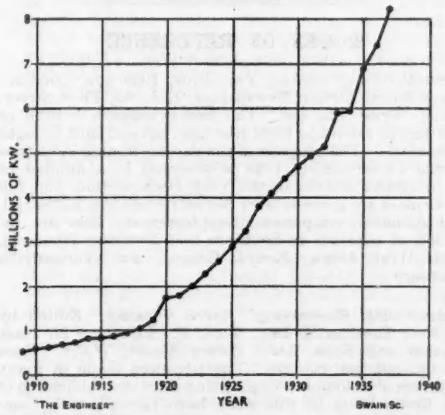


FIG. 7—AGGREGATES OF MAXIMUM DEMANDS OF UNDERTAKINGS, 1909—1937

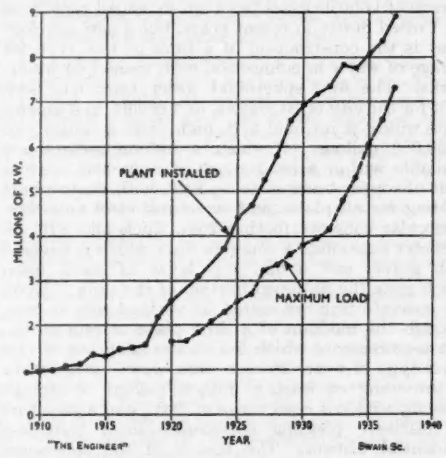


FIG. 8—PLANT INSTALLED AND MAXIMUM LOADS ON GENERATING STATIONS, 1909—1937

French Railway Accident.—Two engine drivers, a fireman, and four soldiers were killed as a result of a collision between an army leave train and a goods train at a junction near Troyes early in the morning of Sunday, January 21st.

New Rolling Stock for the Liverpool and Southport Electrified Lines

In the Derby carriage and wagon works of the L.M. and S. railway new trains are being constructed to replace obsolescent stock on the electrified lines between Liverpool and Southport. The coach work is being carried out to the designs and under the supervision of the chief mechanical engineer, Mr. W. A. Stanier, whilst the electrical equipment is being installed to the requirements of Mr. C. E. Fairburn, deputy chief mechanical engineer and chief electrical engineer. The English Electric Company is responsible for the electrical equipment.

Thirty-four three-car units are being produced, each comprising a motor car, third class trailer car, and composite driving trailer car (see page 112), while in addition, twenty-five two-car units are to be provided each comprising a motor car and non-driving trailer car, of which sixteen have third class trailer cars and nine have composite trailer cars. These two-car units will be used in conjunction with the three-car units so that trains may be made up of three, four, five, or six cars, according to traffic requirements. A schedule speed of about 30 m.p.h. will be maintained by a fully loaded train on the stopping service with stations 1·23 miles apart, allowing 20 seconds for stops. The initial acceleration is 1·6 m.p.h.p.s. for a fully loaded 5-car train and 1·4 m.p.h.p.s. for a 6-car train. To meet the express services, the maximum speed of a fully loaded train is over 70 m.p.h.

Each motor car is fitted with 4 axle hung motors having a one hour rating of 235 H.P. and a continuous rating of 184 H.P. at 580 volts. In the design of the traction motor, particular attention has been given to reduction of weight. Complete with gear case, gear wheel and pinion the weight of a motor is 4484 lbs. The motors are self-ventilated and draw clean air from the top of the coach through ducting and flexible bellows. Roller bearings are employed for the armature.

There are two separate control equipments for each motor car, each set controlling one pair of motors. Each equipment consists of 19 electro-pneumatic contactors, two of which are fitted with extended arc chutes and act as line switches. Power is taken from a bus line fed by third rail collector shoes on motor coaches and driving trailers.

Control follows standard lines in that it gives automatic acceleration to the train under the control of a current limit relay. All the main parts of the equipments are carried underneath the coach. The electro-pneumatic contactors for each pair of motors are carried in two cases and the electro-pneumatic reverser in the third, making three main cases for each of the two equipments on a motor coach. A feature in the contactor design is that both the main contacts and the interlock contacts are at the front of the contactor. A lever enables the magnet valve to be operated from the front so that all inspection can be carried out from one side. Another example of the attention given to ease of maintenance is that all the main cases are so mounted on the underframe that they can be very quickly removed from the coach by sliding out laterally. A spare set can then be substituted and the time the coach has to be out of service is reduced to a minimum. The low tension supply for the control circuits is provided by a 52-volt motor-generator set and alkaline battery of 36 cells. To obtain smooth acceleration and to get full advantage of adhesive weight on the motored axles, particular attention has been paid to the design of the current limit relay, which is of the balanced armature type and is, therefore, not affected by vibration or train movement.

Compressed air for the brakes, electro-pneumatic control, and air operated doors, is provided by a two-cylinder air compressor supplied by the Consolidated Brake and Engineering Company, Ltd. The 600-volt driving motor is controlled in the ordinary way by a compressor-governor, a synchronising wire being used to ensure that the compressors of a train operate simultaneously. One compressor is fitted to each motor car. Current for coach lighting is supplied through an electro-magnetic contactor controlled by a set and trip switch in the guard's van. The coach heaters are also supplied at 600 volts and the heating contactor is controlled by a thermostat.

Access to the interiors of the cars is obtained by 3ft. 9in. wide doors leading into the lobbies. These doorways are closed by double doors which slide back into the body side walls. The doors, which are Alpax castings, are air operated, control being in the hands of the guard. Push buttons are provided on the doors by means of which the passengers may open the doors themselves, if the guard has previously pressed a "passenger open" push button in his control-box. The opening and closing of each door operates an interlock switch which only permits the driver's signal bell to be sounded by the guard when all the doors are properly closed. G. D. Peters and Company, Ltd., were responsible for the electro-pneumatic door operating equipment.

The interior finish of body sides and ends in the third class compartments is composed of plywood panels veneered with Sapelle or Paldao, and the seat ends are in laminated block-board veneered to match. The transverse seats are arranged on either side of a

gangway to seat three persons abreast on one side and two on the other, and upholstered in green uncut moquette. The seats are supported on fixed frames fabricated by welding from light steel pressings. Electric heaters are positioned below the seats. Floors are covered with linoleum laid on felt and cork which is supported by galvanised steel dovetail sheeting laid across the underframe and welded to it. In the first class compartments, arm rests are provided in the seats, which are upholstered in fawn and brown uncut moquette, and a mottled carpet to tone is laid on the linoleum floor covering. The body side finish is in Betula veneered plywood. Photographs are provided on the walls of first class compartments, their place being taken by advertisement frames in the third class. The windows are provided in their upper halves with sliding light ventilators, and the interior metalwork of these is finished in bright nickel. Grab rails, commode handles, and brackets for ceiling grab straps are in aluminium alloy castings and steel tubes covered with "Coverite," "Resistoid," or "Firmoid" finishes coloured to tone with the veneers.

In designing the cars the dual aims of light weight and rigidity have been kept to the fore and the weight figures given at the end of this description show that a measure of success has been attained. With these aims in view it was decided to treat the whole body structure from underframe to roof as one structural unit. The body side and roof are thus regarded as deep inverted truss members and a consequent saving in weight in underframe members is the result. A further advantage in the case of the motor car is that trusses on the solebars below underframe level are avoided, and there is consequently a gain in space available for mounting electrical equipment. It has long been the practice on the L.M. and S. Railway to build the underframes of steel and the body framing of timber with steel panels, but it was decided for this stock to turn over to the construction of steel bodies. This has involved some new plant, principally press tools and spot welding machines, representing a real revolution in the company's practice, and it has been very effective in assisting the realisation of the aims of lightness and rigidity.

Further assistance has been given by the extensive employment of arc-welding, and, in the underframe members, of high tensile structural steel. All the underframe and body framing members are arc-welded together, and the total number of riveted and bolted joints has been reduced to a minimum. Electric spot welding has been introduced for the first time on the L.M. and S.R. for attachment of panels to the body framing and in other parts of the structure.

It was necessary to exercise considerable care in specifying the high tensile steel to ensure weldability, and the specification finally followed was :—

Chemical Composition —	Carbon	0·20 max. per cent.
	Manganese ...	1·4 to 1·6 per cent.
	Chromium ...	0·10 max. per cent.
	Copper	0·60 max. per cent.
	Silicon	0·30 max. per cent.
	Sulphur	0·06 max. per cent.
	Phosphorus ...	0·06 max. per cent.
Ultimate tensile strength ...		37 tons per sq. in. minimum.
Yield point		23 tons per sq. in. minimum.
Elongation on 8in.		18 per cent. minimum.
Cold bend test : The British Standard test piece shall withstand, without fracture, being doubled over until the internal radius is not greater than 1½ times the thickness of the test piece and the sides are parallel.		

The interior partitions and draught screens are fabricated from light steel pressed framing members arc-welded together and covered with steel sheet. The partitions which extend from side to side of the body are fabricated by riveting, while the draught screens and sliding door partitions at the lobbies are spot welded together. To prevent corrosion of the interior surfaces of steel bodyside and roof panels spaces have been left open at the bottom of the bodyside and at the gutters, so that there may be as little difference as possible in temperature and humidity between the air in contact with the outer and inner surfaces of the panels. This result is further sought by the provision of a number of roof extractor ventilators communicating only with the space between the outer and inner roof panels.

Motor cars are mounted on two motor bogies each accommodating two motors as shown on page 112. These bogies are fabricated by arc-welding from high tensile structural steel to the same specification as quoted above, and are of the plate frame type. The wheels are 3ft. diameter at 8ft. 6in. wheelbase, and the axle ends are mounted in Timken tapered roller bearings. The axleboxes and axleguards have liners of manganese steel. Trailer and driving trailer cars are mounted on bogies—see page 112—fabricated by arc-welding from mild steel members. Most of the latter are rolled sections and the general design of the bogie follows traditional lines. The wheels are 3ft. diameter and set at 8ft. 6in. wheelbase. Roller bearing axleboxes are provided by Skefko Ball Bearing Company, Ltd., and some are of the double bearing double row self aligning type, while others have parallel rollers and the end thrust of the axle taken on a bronze pad mounted on the axlebox end cover. All the boxes are oil lubricated.

The buffing and drawgear follow the Company's standard practice. Side buffers are provided, and screw couplings to all cars, at both close-coupled and loose-coupled ends. The only departure from standard practice is in the point of draw, which in this stock is just behind the headstock (strengthened for the purpose) instead of at the main transomes over the bogie centres as is more usual.

The system of braking is the Westinghouse electro-pneumatic. The driver is provided with a self-lapping type of brake controller and a gauge is mounted in each driver's cab indicating the pressure in the brake cylinder of the car in which it is mounted. This assists the driver to estimate the power of any brake application throughout the train. Cast iron blocks are used on the motor bogies, but "Ferodo" blocks on the trailer bogies. Provision is, however, made for readily altering the leverage of the brake rigging on all cars if it is desired to change from cast iron to "Ferodo" blocks or vice versa.

All lighting is by means of 60-watt lamps burning five lamps in series on the 600-volt supply. White opal glass reflectors held in hinged galleries serve to shade and reflect the light. The light fittings are moulded in black bakelite material and are attached directly to the conduit boxes. For train marking purposes, four headlights are provided on the driving ends of the motor car and driving trailer, the code selection being made by turning the headlght reflector through 180 deg. by means of a handle accessible from within the driving compartment. One headlamp of each group has provision for the reception of a slide of ruby glass which can be used as a tail lamp in addition to the normal oil lamp. Destination indicators are recessed into the face of the driving compartments. The new trains are turned out of the shops fully equipped to meet the lighting restrictions of the Minister of Transport. Direct lighting is cut off at a line about 4in. to 8in. below the bottom of the windows. Special shades are fitted to lamps near the entrances to prevent scattered light from escaping into the loading vestibules where the door partitions are blacked off. Normally cylindrical shades are fitted, but where the lights are positioned near luggage racks a special bulkhead fitting is usual.

Below are given in tabular form the weights of the finished vehicles and their component parts, the weight of a three-car train being 88 tons, 15 cwt.

Type of Coach	Tare weight in running order	Weight of one Bogie	Weight per Seat
	T C Q	T C Q	Cwts.
Motor Car	40 10 0	9 14 3	9·20
Trailer Car	23 4 0	4 7 0	4·55
Driving Trailer Car	25 1 0	*4 10 2	6·43

* Same as trailer car bogie with addition of two shoe beams. One bogie only on the driving trailer car is fitted with shoe beams, the other is the same as for the non-driving trailer car.

American Engineering News

Spheroidal Steel Tanks for Water and Gas

The use of spheroidal steel tanks for the storage of volatile gases has been extended rapidly in the United States in recent years, but a new development is the construction of a tank of this type for storage of water in connection with municipal waterworks. The first spheroidal water tank has been built for the city of Brookline, and is 90ft. in diameter at its widest point, and 47ft. high, with a capacity of 1,650,000 gallons, of which a million gallons are available within a head range of only 25ft. It is built of copper-bearing steel plates, with electric butt welding for all plates and structural steel members. A circular concrete footing 20in. thick and 81ft. in diameter surrounds a concrete floor which is covered with gravel and a 6in. top layer of sand, upon which rests the flattened bottom of the tank. Upon the concrete ring are seated 32 vertical ribs or pins, through the medium of a skirt plate or ring girder. The requirements which led to the adoption of this novel type of water storage tank were the necessity of providing at least a million gallons of storage capacity within a head range of 30ft., and a structure of relatively pleasing appearance in a high-class residential district. The theory of the spheroidal design is based upon the shape that would be assumed by an indiarubber balloon resting on a flat surface. The same principle is the basis of design of the steel gas tanks. If the bag or balloon should be partly filled with liquid, the weight would tend to flatten the bag; with gas alone, the shape would be spherical. For a capacity of 80,000 barrels of gasoline—or petrol—under a pressure of 2½ lb. per square inch, the ideal form would be a spheroid 125ft. in diameter and 50ft. high. But as a gas or liquid load alone would cause excessive stresses in the lower part of the shell, the actual shape is modified to a maximum diameter of 108ft. and a height of 75ft. There is no internal framing or bracing. Such tanks have been built with capacities of 2500 to 40,000 barrels, and flatter tanks—130 by 40ft.—up to 100,000 barrels.

American Earth Dam Construction

In the construction of large earth dams two principal methods are employed: rolled-fill embankments, and hydraulic placing of the fill. A report of the American Society of Civil Engineers points out that both design and construction are influenced largely by the relatively recent developments of the science of soil mechanics, but although these have made possible a more rationalised design, experience indicates the need of caution in applying laboratory results to field practice. For dams of the rolled-fill type, almost any type of soil can be used, if proper drainage is provided. With plastic material, compaction should be limited to such a degree that it can be maintained—after saturation—by the weight of overlying material, as over-compaction is undesirable. Foundation soils must be studied, and the horizontal shear beneath the dam, which may be increased by over-compaction, is likely to be a controlling factor in the design. The value of concrete key-walls in joining earth fills to rock is questionable, and such walls have been omitted in several designs. For granular material, a heavy tractor is an efficient compacting element. In practice the compaction is often done partly by the motor trucks depositing material, partly by tractors which spread and level the layers, and partly by tractors hauling rollers of the ordinary or "sheep's-foot" types. In hydraulic-fill practice the tendency is to narrower cores, with side slopes of 1 on 3 for the core. At the Quabbin Dam, the material from borrow pits was carried nearly a mile by belt conveyors 36in. and 42in. wide, the end section at the pit being swung in a semicircle to follow the excavator. Conveyance by pumping through rubber-lined steel pipe was successful on straight runs, without bends or curves. There is a general tendency to use flatter slopes, and also to provide settlement gauges. In at least one case steel shafts 3ft. in diameter, with side ports, give opportunities for inspecting, sampling, and testing core consolidation.

Gas and Steam Turbines

Progress of the gas turbine was an unusual subject at a meeting of the American Society of Mechanical Engineers. After years of experiment—mainly in Europe—the combustion gas turbine is now in the commercial stage, with eleven plants in the United States and several installed or under construction in Europe. The Brown-Boveri machine is of the continuous-combustion type, as distinguished from the earlier Holzwarth intermittent combustion machine. Without preheating or reheating an overall efficiency of 15 to 23 per cent. was expected, but gains in overall thermal efficiency at any given temperature can be made by utilising the exhaust gas to preheat the combustion air and to reheat it after partial expansion. The field of the gas turbine lies where cooling water is not available, or gas and oil are cheap. It has an obvious application to blast-furnace blowing by using the furnace gas as fuel. . . . At existing steam-turbine power stations additional power without additional fuel cost may be obtained by the superposing of a high-pressure "topping" turbine to generate 25 to 50 per cent. more power with the same fuel consumption. Or, where waste steam is available at atmospheric pressure, a low-pressure condensing turbine will effect a similar result. Many steel-mill plants offer opportunities for savings in this way. Installation of superposed turbines means new boilers, auxiliaries, and feed-water heating equipment, but requires no change in the condensing equipment. A station, with 20,000 kW of condensing turbines at 300 lb. pressure, could in this way increase its capacity 7400 kW—or 37 per cent.—by installing a 1250-lb. superposed turbine. Installation of low-pressure condensing turbines requires the addition of condensing equipment, but no changes in boilers or auxiliaries. It is of advantage with a constant flow of waste steam, ample cooling-water supply, inadequate boiler feed, or costly fuel.

BOOKS OF REFERENCE

South African Mining Year Book, 1939–40. London: Argus South African Newspapers, Ltd., 85, Fleet Street, E.C.4. Price 23s. net. The twenty-seventh edition of this useful reference book has been revised and brought up-to-date. The progress of the various mining industries in the Union during 1939 is reviewed in a number of authoritative articles in the Year Book section, and full particulars are given of over 750 active mining, industrial, and financial companies. Supplementary lists are included of concerns in Southern and Northern Rhodesia, South-West Africa, Kenya Colony, and Tanganyika Territory.

Automobile Engineering. Seven Volumes. Edited by H. Kerr Thomas, M. Inst. Mech. E. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, W.C.2. Price 7s. 6d. net per volume. The advances made in many branches of automobile engineering since the publication of the first edition of this work have necessitated a considerable number of revisions in the new volumes. A clear explanation of the theory of motor car work in the first volume is followed by detailed descriptions of each of the various branches in subsequent volumes. All the information is given in a clear concise manner and a large number of excellent drawings and illustrations considerably enhance the value of the books. A number of well known authorities were engaged in its preparation and there is no doubt that students will find it a valuable practical guide to current practice and experts will find it a useful reference work. Each volume has a good subject index, but we think that a general index of all the sections would prove a useful addition in either the first or last of the volumes.

Rail and Road

FIRST CLASS ACCOMMODATION ON LONDON'S UNDERGROUND.—From Thursday, February 1st, accommodation for first-class passengers on practically all trains on the underground lines of the London Passenger Transport Board came to an end. The services excepted are the through trains between the Aylesbury and Watford joint lines and the Metropolitan Line.

SOUTH AUSTRALIAN RAILWAYS REPORT.—The annual report of the South Australian Railways show that during the year 1938–39, the earnings totalled £3,133,373, a net decrease on the previous year of £165,711. This brings the accumulated deficit in working to June 30th, 1939, up to nearly eleven and a half million pounds. During the year passenger journeys numbered 17,632,100, and tonnage hauled totalled 2,661,100. Train mileage increased by 66,286 to 6,177,400 miles.

AMERICAN RAILWAY PURCHASES.—Statistics compiled by the *Railway Age* show that during 1939 the railways of the United States purchased materials and equipment to the total value of nearly 1000 million dollars. Of this total just under 259 million dollars was spent on fuel. Orders were placed for 375 engines for home services and of these 95 were steam, 32 electric, and 248 internal combustion engine driven or oil electric. Other rolling stock orders placed were for a total of 54,439 freight cars and 325 passenger coaches.

GAS BAGS ON BUSES.—The Minister of Transport proposes to amend certain regulations so that gas bags may be used on the tops of single deck buses. Existing regulations limit the height of a single-decked bus to 10ft. 6in. It is proposed to increase the permitted height to 15ft. where the extra height is due solely to the adaptation of the vehicle for the carriage of flexible gas containers. Containers are not, in the aggregate, to exceed 150 lb. in weight and the gas pressure must not exceed 1 lb. per square inch above atmospheric pressure.

LOCOMOTIVE BOILER WATER TREATMENT.—An interesting account of the experiences leading up to and following the adoption of locomotive water treatment on the Illinois Central Railroad in the United States is given in the *Railway Age*. It is stated that, prior to the adoption of the lime-soda ash method of treatment in 1904, on the Western lines of the system there was one engine failure per 5000 locomotive miles, owing to bad water. This figure has been reduced to one failure per 10 million locomotive miles. It is stated that prior to 1929 it was necessary to rebuild fire boxes at intervals of eleven to eighteen months whereas no firebox has been renewed on locomotives on these lines within 10 years of installation, and only 10 boxes have been renewed during the last 5 years on the 1523 engines in active service.

LIGHTING FOR L.M.S. PROVINCIAL ELECTRIC TRAINS.—The London, Midland and Scottish Railway Company announces that approval has now been obtained for schemes of interior lighting for the suburban electric services radiating from Liverpool and Manchester, and travellers on those routes will have lights for reading as soon as the necessary equipment can be installed. As, however, the approved scheme involves the fitting of approximately 8600 lights in 400 coaches, and as supplies of metal lampshades and other blacking-out equipment are not always readily available, it may be some time before the whole of the trains are equipped. The services affected comprise those between Manchester and Altrincham (L.M.S. and L.N.E. Joint Line), Manchester and Bury, Liverpool and Ormskirk, Liverpool and Southport, and the Wirral District (Liverpool and New Brighton and West Kirby). The lights are shaded so as to throw the illumination down over the seats and so as to cut off direct rays of light from the windows, the latter being covered by blinds with the exception of sufficient provision for passengers to identify stations.

THE DUTY ON GAS PROPELLED VEHICLES.—During the consideration in Committee of the Gas and Steam Vehicle (Excise Duties) Bill, amendments were moved to reduce further the unladen weight duties on vehicles propelled by home produced fuel. The Parliamentary Secretary to the Ministry of Transport pointed out that these allowances had been carefully considered by experts and on the whole it could be said that the weight allowances erred, if at all, on the generous side. The request that these vehicles, when converted to gas propulsion, should be exempted from taxation went far beyond the Government's original pledge. Such exemption would place petrol vehicles and electrically-propelled vehicles at a considerable disadvantage, and would conflict with the general principle that no undue preference should be given to one type of vehicle as compared with another. A tax such as proposed in the amendments would involve a serious potential loss of revenue to which the Chancellor could not agree. The Chancellor received 12 million pounds in revenue from goods vehicles, and if 50 per cent. of these were converted to gas-propulsion exemption would mean a loss of 6 million pounds.

TROLLEY BUS STORAGE BATTERIES.—In the course of a paper to be presented at the North Western Centre of the Institution of Electrical Engineers, Mr. E. C. McKinnon deals with the use of storage batteries for trolley bus manœuvring. He says that this application has developed rapidly during the past three years and points out that although the Ministry of Transport has increased the unladen-weight allowance of trolley-busses fitted with batteries for manœuvring, battery manufacturers are still limited to a weight allowance of 400 lb. (maximum), because transport managers have taken advantage of the extra weight allowed to increase the seating capacity. Apart from recuperative property, the lead-acid battery has the advantage that, even when exhausted as regards propulsion ability, it will still at low discharge rates maintain the statutory lighting for some hours. The standardisation of trolley-bus batteries is still incomplete. Actual results suggest that the best compromise in battery voltage is 60 volts for propulsion, and 30 volts for lighting, using a series-parallel switch. Lighting standardisation is in suspense as controversy has arisen over the question of series-parallel versus three-wire battery circuits, and also whether the standard voltage for oil-engine starting batteries on commercial vehicles shall be 12 volts or 24 volts.

Miscellanea

THE USE OF GAS.—Statistics issued by the British Commercial Gas Association show that during 1938–39 there were 11,997,447 users of gas in this country.

SULZER OIL ENGINE OUTPUTS IN 1939.—According to official returns we have just received, the total output of Sulzer marine oil engines, both for propulsion and auxiliary service under construction and commissioned by the Sulzer Associated Companies and their Licencees during 1939 was 1,009,600 H.P., while the total output of oil engines for stationary and locomotive use was 93,900 H.P.

ELECTRICITY IN THE UNITED STATES.—According to statistics prepared by the *Electrical World*, electricity generated in the United States during 1939 totalled 123,000 million kWh of which 39,400 million were produced in hydro-electric stations. The total installed capacity of the country is 37,466 million kW of which 26,732 million kW is steam and 9935 million kW water power. The capacity of new plant installed during the year totalled 1,284,830 kW.

TRACTOR TRIALS.—It is announced that the tractor tests, conducted by the Institute for Research in Agricultural Engineering at Oxford on behalf of the Royal Agricultural Society, which were postponed in September last owing to the outbreak of war, are now to be carried out. The original entrants have agreed to take part as time and conditions permit. The entries include one from Bristol Tractors, Ltd., four from David Brown Tractors, Ltd., one from Sale, Tilney, and Co., Ltd., and one from Ransomes, Sims, and Jefferies, Ltd.

TENNESSEE VALLEY IMPROVEMENT WORKS.—During the coming session of the United States Congress the Tennessee Valley Authority is to request permission to proceed with the Colter Shoals project. This is the last of the series of ten dams on the main stem of the river and its estimated cost is 25 million dollars. It is some 40 miles below Knoxville and will provide a 9ft. navigation channel up to that city and will ultimately have a power installation of 70,000 kW. The other nine dams have been authorised and are already under construction or completed. It is expected that there will be a considerable amount of opposition to the new project.

FARADAY MEDAL.—The Council of the Institution of Electrical Engineers has made the eighteenth award of the Faraday Medal to Dr. Alexander Russel, F.R.S., a Past-President of The Institution. The Faraday Medal is awarded by the Council of the Institution not more frequently than once a year, either for a notable scientific or industrial achievement in Electrical Engineering or for conspicuous service rendered to the advancement of electrical science, without restriction as regards nationality, country of residence, or membership of the Institution. The Council of the Instituion has elected Mr. Roger T. Smith, one of its Past-Presidents, to be an Honorary Member.

CYLINDER WEAR.—The Institution of Automobile Engineers has just published a book "Collected Researches on Cylinder Wear" by Mr. C. G. Williams, the Director of the Institution's Research Department. In the compilation of the book, an examination was made of more than a hundred articles and papers which have appeared within recent years in the technical press, but only the more important of the contributions, particularly those which present numerical data, have been discussed. The book summarises the information published on the subject and indicates the direction in which further data would be of value. Later chapters deal with the experiences of manufacturers and operators and the four interim reports on experiments carried out at the Research Department are included, together with a report on an investigation of cylinder liner materials.

LIGHTING RESTRICTIONS.—A new Order governing the restrictions on lighting has been made by the Minister of Home Security. It repeats the requirements of the Lighting Restrictions Order of last September making it unlawful to display lights from windows during the hours of darkness. It includes the modifications introduced more recently, namely, those making the "black-out" period last from half an hour after sunset until half an hour before sunrise, enforcing the use of the authorised motor headlamp masks, and permitting the modified street lighting in all but the specified districts near the coast, shop window lighting, shop signs, hand torches, &c. It also contains certain new provisions affecting headlamps, trailers, and public service vehicles. The Order came into force on January 22nd and the new type of headlamp mask or one giving an equivalent performance is now compulsory, and rear lamps must be carried not higher than 3ft 6in. from the ground except in the case of public service vehicles. Any other new Regulations will not come into force until February 1st. Further, the new type of headlamp mask does not become compulsory for public service vehicles until March 1st, and the requirements for trailers do not operate until that date.

SYNTHETIC MICA.—A new synthetic material with similar properties to mica and having Bentonite as its base has been developed in America by Dr. E. A. Hauser. According to the *Electrical World* a gel of Bentonite and water was found to harden gradually under room temperatures. Spread into thin films and heated, the resultant coherent, self-supporting sheets proved non-inflammable under temperatures ranging to 700 deg. Cent. and also were resistant to oils and organic solvents. Dry, the film had satisfactory electrical insulation properties, including a breakdown strength of more than 3000 volts per mil. When the gel was dried in films by infra red light, using the new General Electric gold-plated reflectors, and treated with appropriate chemicals, for example, lead acetate, the substance took on water-proofness as an added mica-like property. "Alsifilm," as the material is known, can be produced in films ranging from 0·001in. to 0·005in. in thickness and in practically any width or length. For greater thicknesses it can be laminated with or without the addition of synthetic resins or other impregnants. It is translucent and may be dyed any colour while still in the gel state, or mingled with carbon black, which seems to add to its resistance to tearing.

Air and Water

SHIPPING CONVOYS.—Up to 17th January the number of British, Allied, and neutral ships escorted in British convoys was 6872 with a loss of only 14 vessels, the losses remaining stationary at one in 500.

ADMIRALTY APPOINTMENT.—The following announcement is made by the Admiralty:—Sir Athol L. Anderson, will retire from the post of Civil Engineer in Chief on January 17th, 1940. He will be succeeded by Mr. F. A. Whitaker.

BRITISH BALLOON BARRAGES.—The expansion of the balloon barrage in this country continues at high speed, and a number of new coastal barrages are in process of formation. The barrage now extends over 700 miles of land and sea.

DIRECTOR OF SHIP'S STORES.—The appointment is announced of Captain J. Elliot Seager as Director of Ship's Stores for Great Britain and Northern Ireland. He has been deputy director of the organisation since the outbreak of war.

ITALIAN LINER DISASTER.—When about 50 miles south of Marseilles on the morning of Sunday, January 21st, the Italian liner "Orazio" caught fire and was abandoned as a total wreck. Reports state that over 100 of the 645 passengers and crew the liner was carrying have lost their lives.

SHIPBUILDING ORDERS.—It is understood that a new department to be known as the Department of the Deputy Controller of Dockyards and Shipbuilding is being formed at the Admiralty. It will co-ordinate naval and mercantile shipbuilding orders and fix priority of material supplies to the yards for the purpose.

DUTCH AIR LINER DISASTER.—A passenger liner of the Royal Netherlands-Indies Airways crashed in the sea near the island of Bali on January 22nd, and the five passengers and crew of three were all killed. The cause of the disaster is not yet known, but it is believed that the machine was caught in a sudden squall.

ITALIAN LONG DISTANCE AIR RECORD ATTEMPT.—An attempt to set up a new long distance air record by an Italian Savoia Marchetti 75 machine which started from Rome on January 14th failed when the machine was forced to land on an island off the coast of Brazil after covering a distance of just over 4370 miles. A severe storm and head winds which were encountered forced the machine to descend after flying for 32 hours 25 minutes.

NORTH EAST COAST INSTITUTION.—The North East Coast Institution of Engineers and Shipbuilders announces that owing to circumstances connected with the war, Mr. F. A. Perkins is unable to give the paper on "High-Speed Diesel Engines for Marine Purposes," which he had intended to read on February 9th. The paper will be replaced by one by Mr. W. S. Burn, entitled "The Application of the Heavy Oil Engine to Aircraft Propulsion." This paper is being prepared at short notice, but will present the results of original investigations on the subject by the author.

ANOTHER EMPIRE AIR TRAINING SCHEME.—The British Government has approved the establishment of an Empire air training scheme in Southern Rhodesia. The cost will be borne by the United Kingdom Government, the Southern Rhodesia Government contributing thereto. Whilst the equipment and the majority of the instructional personnel and pupils will be provided by the United Kingdom Government, the schools to be established under the scheme will be under the control of the Southern Rhodesia Government, and the existing training organisation in Southern Rhodesia will be incorporated in it.

POWER OPERATED GUN TURRETS ON AIRCRAFT.—Particularly good results are said to have been obtained with the power operated gun turrets now fitted to certain types of machines of the Royal Air Force. The high speed of modern aircraft makes it difficult for a gunner to hold a gun against the wind when firing from a manual turret. With the power operated turret a gunner can deploy his battery of guns in any required direction without effort and with steady aim. These turrets are fitted as standard equipment on most British bombing machines and some new type R.A.F. fighting machines are also similarly equipped.

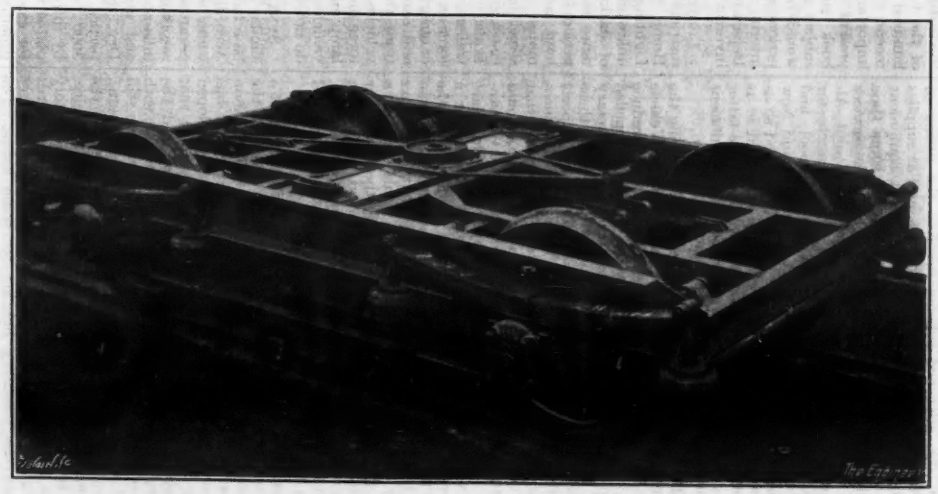
SHIPYARD WAGES.—Representatives of the Shipbuilding Employers' Federation and the Confederation of Shipbuilding and Engineering Unions met recently in conference, and the Unions presented their claim for an advance of 10s. per week to plain timeworkers 21 years of age and over with an equivalent advance to pieceworkers. Mr. J. W. Stephenson, President of the Unions' Confederation, was spokesman for the Trade Union side. Mr. H. Main, the President of the Employers' Federation, in reply said that it would be necessary for the case of the Unions to be referred for consideration to the Central Board of the Federation, and to Local Associations. The conference was then adjourned.

BRITISH TANKER LOSSES.—The German Press and broadcasts in foreign languages continue to proclaim that the losses of British oil tankers have been very heavy. The sinkings of more than twenty British tankers have been claimed by the enemy. As an example of how these claims are exaggerated the following extracts may be quoted from a list of British ships alleged to have been sunk, which was published in the *Bremer Zeitung* on December 29th, 1939. This list contained the names of twenty or more so-called British tankers which Germany claims to have sunk. Six of the vessels quoted in this list and shown as tankers are ordinary cargo vessels and not tankers at all. These are the "Rio Claro," "Gartavon," "Aviemore," "Kafiristan," "Akenside," and "Horsted." These ships total about 20,000 tons gross. The same list claims as having been sunk the tankers "Appalachee," "Tornus," and "Abbeydale" whereas these ships, which total some 25,000 tons gross, are all safely pursuing their duties. The small coastal tanker "Africa Shell," of 706 tons gross is shown in this list as of 7060 tons. She was sunk by the battleship "Admiral Graf Spee." The tanker position of the Allies is, at present, better than it was at the outbreak of war.

ROLLING STOCK FOR THE L.M.S. LIVERPOOL AND SOUTHPORT ELECTRIFIED LINES

(For description see page 109)

TRAILER CAR BOGIE



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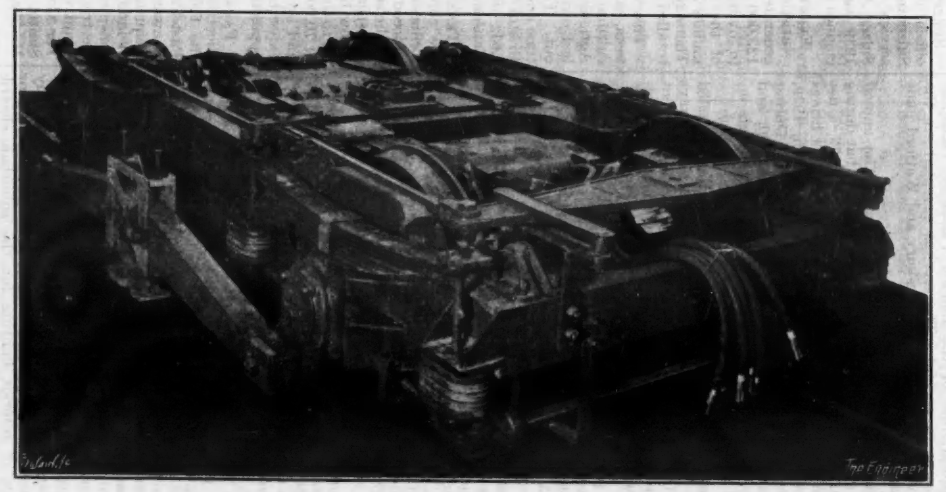

MOTOR CAR BOGIE

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NOTICES TO READERS

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MAGNETIC MINES

WHEN, a few weeks ago, it was discovered that the Germans were using magnetic mines off our eastern coast, it was believed by many people that this was a new war invention. As a matter of fact magnetic mines are at least twenty-five years old, for large quantities of them were made in this country during the Four Years' War, and were laid off the Belgian coast. The present German mine is a rather clumsy and costly adaptation of the old British mine. The magnetic mine derives its name from the employment of a magnetic trigger in place of the usual mechanical one. This trigger may do one of two things. It may fire a mine lying on the sea-bottom, or it may release a mine from a sinker. In the former case the explosion has to take effect through the depth of water existing between the bottom of the ship and the mine; in the latter the mine is released when the bow of the ship passes over the trigger, and floating upwards makes contact with the ship towards its middle or stern. A very rough calculation will show that there is plenty of time for this action to take place, particularly with the relatively slow speed tramps which are the usual victims. Nevertheless, for various reasons, the fixed mine is preferred. It is lighter, and less cumbersome, important considerations if it is to be dropped by aeroplanes or submarines, and it is less costly. During the Great War, the Admiralty Research Department examined the whole problem scientifically and practically, and made out a complete diagram showing how the effect of the explosion fell off as the depth between the ship's bottom and the mine increased. Speaking broadly, it may be said that when the depth was more than 10ft., a substantially built ship would not be sunk by the explosion. Hence the practice of sowing fixed magnetic mines in shallow estuaries and near the coast. Where the danger exists it is manifestly to the advantage of the ship to avoid such areas at low tide.

In the absence of detailed information, it may be interesting to consider the broad principles employed in the operation of magnetic triggers. Of whatever design, they act by the disturbance of the earth's magnetic field by a magnetic body—a steel ship. The earth's magnetic field is composed of lines of force extending between the North and South poles. A magnetic needle on a vertical pivot lies in these lines of force. But if any magnetic substance is introduced into the field it bends the lines of force to one side and the needle, still remaining co-axial with the lines, turns in agreement with their new direction. Furthermore, there are diurnal and secular variations in the direction of the lines. Suppose now that the trigger consists of no more than a magnetic needle which makes an electric contact to fire the mine when disturbed by the approach of a ship. It is obvious that in such circumstances it would only happen by the merest chance that the fixed element of the contacts was in the right position, for in the first place it is quite impossible to orient the mine in a particular aspect when sinking it, in the second, diurnal and secular variations of the field would alter the relative position of the moving and fixed elements of the contacts, and finally the mine might have been dropped in a position, say, near a steel pier or a sunken wreck, at which the lines of force were subject to a permanent displacement to one side. For these reasons it is necessary to have an abutment for the fixed part of the contact which will adjust itself to the permanent conditions caused by the orientation of the mine and the presence of permanent magnetic bodies, and to the small variations in the earth's magnetic field. This desideratum is met in the following very ingenious manner. Two magnets on the same vertical axis are employed. One of them is heavy in itself and is heavily damped so that its oscillation is extremely slow. When the mine is sunk this magnet adjusts itself to the local conditions, taking up a fixed position in respect of them. Moreover it quietly adjusts itself to the diurnal changes of the earth's magnetic field. Hence it provides just the abutment that is wanted for the fixed element of the contact. The second needle, on the contrary, is very light and very free. Normally it lies above and in line with the heavy needle and if any sudden distortion of the magnetic field takes place it responds long before the heavy damped needle can do so. Thus it is a simple matter to arrange for a contact to be made by a switch one part of which is on the light magnet and the other on the heavy one. As a matter of fact, the contact is usually made by the flick of the needle as being more convenient than a direct fixed contact. Under a disturbing force rather suddenly applied a light needle flies far beyond its position of rest and then oscillates. It has been found best to use the back flick to make the contact. An interesting question rises at once to the mind. Owing to the extreme delicacy of the arrangement described it would seem probable that disturbances of a small nature would easily set off the mines. That actually happened in the earlier experiments when it was found that the firing of one mine in a field might set off the whole field. A lagging device was therefore introduced and is always fitted. It prevents the firing of the mine, or the release of the mine from a sinker, in undesired circumstances. There is furthermore the usual delay device which enables mines to be laid without danger to the minelayer.

The problem of disposing of magnetic mines is exercising the attention of many minds and experiments are being constantly carried out. Manifestly what is required to explode them on site is some device that will distort the earth's magnetic field. Electrical engineers know of various ways of doing that and the problem is to select the best from a variety. The alternative is to render the mines inoccuous and drag them from their bases to a position where they may be safely destroyed.

Post-Graduate Training

IN his Presidential address to the American Society of Mechanical Engineers on December 4th, Professor A. G. Christie took for his subject the "Postgraduate Training of Young Mechanical Engineers." We could wish that we had the space and the paper to reprint the address in full. It is contentious; not everyone will agree with Professor Christie on his main arguments. Yet all will agree that he puts his case as an engineer rather than as a professor. We have heard endless discussions on education, and have generally noticed that teachers are too much concerned about scholastic matters—degrees and exams. and scholarships, and things of that order. That is natural; everyone must think and act in his own vocation. The ancient universities have found it particularly hard to fight against that inclination. By all their traditions, scholarship is an honourable thing by itself and of itself. There is no need for it to be useful; indeed it loses caste if it *is* useful. But if it must be turned to the service of mankind then it is better that it should spring from the scholarly examination and exigesis of ancient writings than from new, practical experience. Admirable examples of the University attitude—as it was, let us say—are to be found in the difficulty that Lister and Pasteur and their predecessors in surgery found in overcoming the opposition of orthodox tradition. In America one would expect a very different condition of affairs, but even there, we fancy, tradition has been allowed to grow, nay, has been fostered, as something aged and respectable. It is, therefore, refreshing when the Professor of so famous a university as the Johns Hopkins turns away his attention from scholastic things and devotes it to the training of young engineers after they have passed out of the hands of professors into those of industrialists.

Professor Christie's address is in substance an attack on American employers for their indifference about the post-graduate training of young engineers. He leads off by asserting that America has too good a conceit of herself and that "at present more thought is given to short working hours, high wages, and social security than to the industrial developments that will assure these ends," and he goes on, "American industry, in order to survive and prosper in international trade, must develop an objective training programme for young mechanical engineers. The definite objectives of such training

should be: (*a*) self confidence of our engineers based on thorough technical instruction; (*b*) their aggressive initiative through encouragement by industry both in original invention and design, and in the introduction of new production methods; and (*c*) adequate financial remuneration during training periods with ample rewards for accomplishments in invention and production." Professor Christie makes no attempt, as others have done, to present in outline or detail a specific method of industrial training; he is concerned only with broad principles. But he does express some doubt whether the average training course gives as much opportunity to observe and learn technical processes as, for example, a medical student sharing in hospital duties is given. Older engineers will make the comment that in their days of apprenticeship, when there was a lack of method and no specific and ordered instruction, the young engineer who was really keen made his own opportunities for learning something about all phases of his craft. It is possible that Professor Christie, even whilst he is urging employers to adopt more method, has a friendly eye for the method by which he himself was trained. At any rate he writes: "The more thorough the graduate's knowledge of every phase of the business and its machinery, the more competent will he become in later years. Too often there is a tendency to shorten the time spent in the shops or over a drawing-board. This is a mistake that needs correction. Our industries should not have to depend upon foreign sources for designers and draughtsmen." The last sentence touches us here, too, upon a sore spot; in too many cases foreigners are employed for work that Britons could have done equally well, and perhaps better, had employers had the foresight to present them with opportunities. "Emphasis," says Professor Christie, "should be placed upon the training of men for the design, development, and research necessary," to ensure the introduction of new and better products, at lower cost, as the result of engineering developments.

There will always, to the end of time, be differences of opinion about the best way of training engineers. Many people who look with suspicion upon works classes and training benches hold to the old view that what a man learns for himself he knows best. They are doubtful about detailed instruction, suspecting that experience is the best teacher. They point proudly to the tradition of British invention and claim that the major part of it is due to self-educated men. Their case cannot be neglected, but it is possible that it overlooks the change that has come over industrial engineering in the past fifty years. The old simple machine tools and traditional hand methods, the few old materials, the few types of mechanism could be learnt by observation and practice. But it is very different now. The properties of new metals cannot be learnt in a haphazard fashion, types of machines are so numerous that practical acquaintance with them all by an apprentice is impossible, and a thousand and one changes have taken place in the use and design of mechanisms. All these things, quite apart from the introduction and development of new industries, and from the increasing impact of pure science upon industry, have altered works conditions out of all recognition. They have made it necessary to introduce method into workshop training and have swept away many of the qualities which seemed good to the fathers of the present generation. One of those qualities was the individualism encouraged by the old slapdash method. The men who mattered were those who fought their way to the top. Now all are carried upward by an escalator and delivered with the regularity of motor cars leaving the assembly line. We know that the product is very useful in industry; that it knows how to carry on the routine work, and has an adequate understanding of what it is doing. But there is just a little danger that men are being turned out all too much to type, and that they lack the character which was formed by the cruder and harsher methods of earlier days. Industry requires a great number of standardised mechanics and mechanical engineers, but it also wants men of inventiveness as Professor Christie says, and the making of them is much more difficult.

Literature

Le Corporatisme ancien de Construction navale en France. By A. VINTRAS, JEHAN BANSE, G. DECOMBLE, and PIERRE ABBAT. With an introduction by PAUL AUGUSTIN-NORMAND. Paris: Académie de Marine, 3, Avenue Octave-Gréard. 1939. Price 100 francs net.

IN this work the operation and organisation of the "corporations" of four French ports are described. By corporations are meant the professional organisations which are known in England as guilds, and which flourished in France in the Middle Ages and under the "Ancien Régime," or the period from the Renaissance to the French Revolution. As is well known, the guilds still exist in London, without, however, from the professional point of view, having preserved their original functions. Nevertheless, they have always played a political and, it might be added, a philanthropic part, in the progress of the particular trades which some centuries ago brought them into being. Such is the case of the Worshipful Company of Shipwrights, corresponding in this country to the corporations governing the merchant and naval ship construction in the four French ports described in the book. These corporations, and those of other trades, were evolved during a period of eight centuries, and it was not until 1791, at the approach of the new order in France, that they disappeared. For the same reason and at about the same time many of the guilds in this country saw their professional privileges curtailed or abrogated.

Fifty or sixty years ago, two very talented writers—the Baron de Vogelsang, in Austria, and the Marquis de la Tour du Pin-la Charce, in France—discussed the unchanging relation to natural conditions of life of the principle which had governed ancient Greece and Rome, and which resulted in ordering during eight centuries the economic activity of the most civilised part of Europe. They advocated a return to this principle, in a form which would be appropriate to the moral and material evolution of labour.

Their teaching inspired an increasing number of followers. Numerous unrelated organisations, based on corporative ideas, were successively brought into being in many countries. Pope Leo XIII and Pope Pius XI extolled the idea of guilds in their social encyclicals. Several national leaders—Mussolini, Dollfuss, Schusnigg, Salazar, Hitler, &c.—have even claimed to have put the principle into effect, but they have done so in debatable forms, more likely to discredit the conception than serve it. In any case, the application of the principle must necessarily vary according to the branch of economic activity to which it is applied, and even in any one branch several variations are possible.

Modern applications of the corporative idea have inspired an important literature, dating from the works of la Tour du Pin, but that which is devoted to the ancient guilds is still more important, although less profuse. Two or three years ago, the troubles which paralysed French production and seemed to endanger the country's social order itself, led several highly placed persons in the shipbuilding industry to study with redoubled attention economic and social problems. They concluded that the corporative idea was sound, but were handicapped in their research by a lack of literature dealing with the old-time guilds which governed the shipbuilding industry, from the ancient traditions of which they thought to gain inspiration. Most of the works available described the merchant and artisan guilds, and no serious or useful contribution had been published in France or elsewhere describing the history of the shipwrights' guilds. It is this gap which, at their request, the Académie de Marine has attempted to fill in the volume before us.

In the introduction, Monsieur Paul Augustin-Normand, a director of the company bearing his name, and descendant of a famous line of French shipbuilders, traces in general terms the growth and structure of the shipwrights' guilds in France, their charters, and their regulations.

As already mentioned, the work is divided into four sections, each of which deals in detail with the history of ship construction and the organisation of the shipwrights' guild of a separate port. Each of the four authors has made himself responsible for one section. It appears that the guilds were organised in slightly different ways according to local peculiarities, and by comparing the four accounts a fair cross-sectional view of the shipbuilding organisation and labour conditions of those times may be obtained. The ports described are Honfleur, Fécamp, Nantes, and Marseille, and numerous illustrations, reproduced from old prints, harbour plans, and sketches, illustrate the text. Accounts are given of the working conditions of that date, and in an appendix to the first section, dealing with the port of Honfleur, contributed by Monsieur A. Vintras, documents of various transactions including working regulations, apprenticeship contracts, and agreements between masters and men are reprinted.

From the conclusion of the second section, contributed by Monsieur Jehan Banse, describing the work of shipbuilding at Fécamp, we translate the following passage: "Steel and modern processes upset naval construction from top to bottom, and the ancient marine guilds, used to sails and wooden ships, were faced with a total eclipse or a complete reorganisation. But, although on the threshold of their decline, they have bequeathed to us a legacy of lessons to be learnt from their at times triumphant career, such as craftsmanship, love of work, and order and method in work."

We have no hesitation in recommending students of naval architecture and all others interested in the historical aspects of shipbuilding to read this work. Its value to naval historians, workers in the shipbuilding industry, and students of social and economic problems is great, but persons less serious in their studies will find much of fascinating interest in dipping almost at random into its pages, for the accounts abound in details of the life and life's work of that fast disappearing figure, the genuine craftsman.

Electrical Timekeeping. By F. HOPE-JONES, M.I.E.E., F.R.A.S. London: The N.A.G. Press, Ltd. 10s.

BOOKS which give a complete survey of the progress of any branch of science, from its earliest stages to the time when it becomes a recognised asset to the community, rarely have the advantage of coming from the pen of one who is himself a pioneer in the field which he describes. Still more rarely are such accounts written without the author falling into the error of giving an undue personal bias to his own achievements. In this new work, "Electrical Timekeeping," Mr. Frank Hope-Jones has embodied most of the advantages to be gained from a close personal connection with his subject, and few of the disadvantages likely to be found when he must, perforce, contrast his own successful efforts with the failures and successes of others.

That electrical clocks have a history of rather less than a century, and that they were for so long a byword for inaccuracy, may seem incredible to those who only know them in their present efficient forms, but the early struggles of those experimenters who first essayed to make the electrical and horological sciences run in double harness show how great was the difficulty of securing the correct relation between them.

As Dr. H. Spencer Jones, the Astronomer Royal, remarks in his interesting foreward to the volume, "If, at the present time, something approaching perfection has been reached in precision time keeping as the direct result of the application of electricity, it is because the successes and failures of many investigators during the course of a century have combined in helping to make clear the right lines upon which progress could be made." It is, however, somewhat surprising to find that the basic principles of accuracy in electrical timekeepers were so persistently evaded, or perhaps it would be more true to say were so long ignored by those whose very experiments should have led them to a better understanding of the problem. The whole story is one of attempts which failed simply because the essential requirements of timekeeping were not complied with, and of errors of principle repeated when their fundamental incorrectness should have been long realised. Despite this, or perhaps because of it, the story makes fascinating reading.

The book begins with a brief note on mechanical clocks, but does not do more than give the bare information necessary for a true appreciation of what is to follow. At the conclusion of this first

chapter a neat classification of the various types of electrical clocks is presented, and a clear guide set out for the general sub-division of the details contained in subsequent pages.

The work of Bain, the first inventor of electric clocks, is dealt with in the second chapter, and his inventions, despite their manifest faults, are described fairly and without prejudice. In remarking that it is impossible to do more than to praise Bain as a pioneer, the author is only telling the simple truth, for the system was a failure, and did much to arouse the prejudice against electric clocks which has survived until almost our own time. The work of Wheatstone, who followed Bain, did little to improve matters, for he again missed the supremely important point that the pendulum, which is the basic component of time measurement, must be free from interference if accuracy is to be attained.

Synchronisation, applied both to pendulums and to the dials of numbers of ordinary clocks, next engaged the efforts of experimenters, and a certain measure of success attended their researches. The detailed account of this stage of development occupies two chapters, after which Mr. Hope-Jones passes to the control of rotary motors from pendulums. This aspect of electrical horology is one that has had wide applications in more recent times, the most notable being, perhaps, the Post Office speaking clock popularly known as "TIM." A brief description of this clock forms the concluding part of this chapter.

From thence onwards through seventeen chapters the development of the independent and self-contained electric clock is traced, and it seems that nothing of real importance in the story has been omitted. The really important advance came when gravity was used to transmit to the pendulum the energy necessary to maintain its arc, and it is significant that it is at this point that the writer himself appears as a contributor to the science of electrical timekeeping. Due credit is given to contemporary inventors, but, even so, the principles on which the work of Mr. Hope-Jones was based are so plainly correct that their mere recital is convincing.

They formed the basis of the now well-known Synchronome-Shortt free pendulum clock which has secured such an honoured position in the world of precision timekeeping, and the story of this clock, told in a delightfully attractive manner, is one of the most interesting parts of the whole book. Others attempted the task of securing a "free pendulum" with varying degrees of success, but it was Mr. W. Hamilton Shortt who really achieved the outstanding advance.

Leaving the sphere of pendulum operated timekeepers, the next sections deal with the developments which have really popularised electric clocks with the public as a whole, namely, the operation of synchronous timekeepers from controlled frequency alternating current supplies. The underlying principles of the system, which at one stroke confers the blessing of accurate and dependable time on every consumer, are covered in a manner at once sound and easily appreciated. Not only are the familiar clocks themselves dealt with, but the other part of the story, the control which must be exerted on the generation of the current and its maintenance at the desired frequency, is covered very fully. It is shown that the earlier efforts which culminated in the production of the accurate and independent master clock are, in fact, closely allied with the control of frequency, the latter really serving the purpose of amplifying the former and making it available to all.

In the last chapter, entitled "Timekeeping at Sea," the peculiar problems set by this kind of service are dealt with in an able manner, and the difficulties arising out of changes of longitude, as well as the methods devised for their solution, are discussed.

An interesting glossary and a complete index conclude the book, which is one of the most able works of its kind. Many of the illustrations are not entirely new, for they appeared in a former work by the same author, entitled "Electric Clocks," but the account then given has been re-written and brought up to date, and a number of additional figures are to be found in the later part of the present volume. Some interesting plates are scattered through the various chapters, and the frontispiece is specially noteworthy.

Some errors of omission are likely to creep into a work of this kind, and this book is no exception. Some aspects of the application of electricity to large clocks have been left out, including the work of several large firms who have evolved systems to operate in conjunction with both half-minute impulse and synchronous circuits. Other omissions lie in the fields of the industrial applications of electrical time service, and some modifications of master clock construction by various makers are also left out, but these gaps do not really detract from the story to any considerable extent.

Perhaps the greatest merit of the book is the author's happy knack of writing in an easy and pleasant style which suggests that he is explaining his subject to an interested friend rather than producing a scientific text book. As a result of this, the story proceeds smoothly and holds the reader's interest.

A word of criticism must be levelled at one or two of the illustrations. Some are a little sketchy and diagrammatic, particularly in the early chapters and in the part dealing with the secondary or impulse dials operated from the master clock. Carefully produced drawings of greater accuracy would have been an improvement, although those used are clearly understandable. The letter-press and the plates are of a high standard, the type face selected being clear and easily readable, whilst the paper gives good reproduction of the line drawings.

We may perhaps be allowed to add a word as to the interest of a volume of this kind to the general reader. The clock is a machine and every machine must of necessity have mechanical engineering features. When, moreover, the hunt for supreme accuracy through the medium of mechanism is afoot the subject becomes not only alluring to the true mechanician, but has valuable lessons for him whatever his vocation may be.

BOOKS RECEIVED

Timber. By Richard Jefferies, B.Sc. London Draughtsman Publishing Company, Ltd. Epsom: 1, Links Road. Price 2s. net.

Everybody's Book of Electricity. By R. Barnard Way. London: Percival Marshall and Co., Ltd., 60, Kingsway, W.C.2. Price 1s. net.

Engineering Materials. By A. H. White. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 30s. net.

Lubricants and Lubrication. By James I. Clower. McGraw-Hill Publishing Co., Ltd., Aldwych House, London, W.C.2. Price 33s. net.

The Quality of Coke. By R. A. Mott, D.Sc., and R. V. Wheeler, D.Sc. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 36s.

The Disposal of Sewage. By T. H. P. Veal. Second edition. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 10s. 6d. net.

Theory of Machines. By Louis Toft, M.Sc., and A. T. J. Kersey. Fourth edition. London: Sir Isaac Pitman and Sons, Ltd. Price 12s. 6d. net.

Cutting Tools for Engineers. By A. H. Sandy, A.M.I.P.E. London: Crosby Lockwood and Son, Ltd., Stationers Hall Court, E.C.4. Price 3s. 6d. net.

The International Mercantile Diary and Year Book, 1940. London: The Syren and Shipping, Ltd., 44 and 46, Leadenhall Street, E.C.3. Price 12s. 6d. net.

Builders' Materials. By Bernard H. Knight, D.Sc., and Rena G. Knight, M.Sc. London: Edward Arnold and Co., 41 and 43, Maddox Street, W.1. Price 15s. net.

Metallurgical Analysis and Assaying. By J. Stewart Remington and F. L. Jameson. London: Technical Press, Ltd., 5, Ave Maria Lane, E.C.4. Price 5s. net.

Mechanics Applied to Vibrations and Balancing. By D. Laugharne Thornton, M.A. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 36s. net.

A Text Book of Heat. Parts I and II. By H. S. Allen, D.Sc., and R. S. Maxwell, B.Sc., London. MacMillan and Co., Ltd., St. Martins Street. Price 10s. 6d. net each.

The Practical Engineer Pocket Book and Diary for 1940. Edited by E. G. Beck. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 2s. 6d. net.

Planning, Estimating, and Ratefixing. By A. C. Whitehead. Third edition. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Kingsway, W.C.2. Price 10s. 6d.

Strength of Materials. By F. V. Warnock, M.Sc., Ph.D. Fourth edition. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Kingsway, W.C.2. Price 10s. 6d. net.

The Physics of the Divining Rod. By J. Cecil Maby, B.Sc., and T. Bedford Franklin, M.A., F.R.S.E. London: G. Bell and Sons, Ltd., York House, Portugal Street, W.C.2. Price 21s. net.

The Railway Handbook, 1939–1940. Compiled under the Direction of the Editor of "The Railway Gazette." London: Railway Publishing Company, Ltd., 33, Tothill Street, S.W.1. Price 2s. 6d. net.

1812–1899, *John Brunton's Book: Being the Memoirs of John Brunton, Engineer, from a Manuscript in his own hand.* London: Cambridge University Press, 200, Euston Road, N.W.1. Price 7s. 6d. net.

Practical Microscopical Metallography. By Richard Henry Greaves, D.Sc., and Harold Wright, B.Met. Third edition. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 18s. net.

Second Year Engineering Science: Mechanical. Second edition. By G. W. Bird, Wh. Ex., B.Sc. Revised by B. J. Tams. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Kingsway, W.C.2. Price 6s. net.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

BUSINESS TRAINING AND NATIONAL SERVICE

SIR,—Lord Derby and others have emphasised the importance of useful occupation being provided for the years immediately preceding the age at which a young man will normally report for National Service, a time when the keenest of them are eager to have probationary experience of the work which they intend to do in life. The important bearing of this difficult problem upon the country's future export trade will be apparent, and with the intention of assisting in its solution the Dunlop Rubber Company has formulated a training scheme which it is proposed to introduce almost immediately. The training will aim to provide for selected young men a commercial background which will be useful to them when the war is over and their military or other service ended. The number who can be trained by any one industrial organisation is necessarily limited, and it therefore occurs to me that other national or internation undertakings may be willing to consider the adoption of some such plan for the well-being of the individual and the nation. To any such the Dunlop Company will readily furnish details of its own proposals. J. GEORGE BEHARRELL, Chairman.

Sixty Years Ago

GOOD TIMES AND BAD

FROM the beginning of 1874, until towards the end of 1879, a great depression of trade existed throughout the whole world. Then prices began suddenly to rise and many people speculated on the causes of, and remedies for, bad trade. A widespread belief was to the effect that the whole subject was a mystery, and that the periodical return of "bad times" could be looked upon only in the same way as our forefathers had regarded the periodical return of the plague. Others, less fatalistic, held that it was entirely a matter of finance and of the current value of the precious metals. Yet others argued that it was bound up with the question of food supply, some even going so far as to trace a connection between it and spots on the sun. Discussing the subject in a lengthy leading article in our issue of January 30th, 1880, we advanced the simple proposition that trade was good when much money was being spent on new industrial enterprises and bad when little was being so expended. We laid stress on the word "new." The supplying of established wants was, we said, never sufficient to keep the industries of such a country as ours actively employed. The capital and labour embarked in our industries were much greater than were needed for the supply of such wants alone. A large part had therefore to seek employment in new fields to which operations had not previously extended. All who had been concerned in the management of a manufacturing business knew, we said, that the large and good orders which really kept the place busy came either from new customers or from old customers launching out in some new direction. The ordinary hand-to-mouth orders covering the supply of daily requirements were very useful but they were not those which enabled a manufacturer to carry on his works at a profit. Taking the railways as an example we argued that the construction of a new line was at least ten times as advantageous to the industries supplying the material as the day-to-day maintenance of the line after it had been built. Going to history for support of our proposition we referred to the period of bad trade between 1816 and 1819 which followed the battle of Waterloo. By 1824 trade had been restored to a sound and satisfactory condition. Then in 1825 the South American States were recognised as independent. Beliefs in their immediate future were however falsified and in December, 1825, a severe trade crisis developed. Depression lasted until 1834. The following year saw the first railway mania, but in 1837 depression spread to this country from the United States. A fresh partial crisis in 1839 was succeeded by a period of trade revival until in 1847 prices fell enormously and a deep but not prolonged depression settled over industry. In 1849 gold was discovered in Australia and California and trade revived. Until 1857 business remained good but in that year a crisis in the United States produced a similar disaster in this country. Prosperity returned in time and lasted until 1866 when, following the passing of the Limited Liabilities Act and an enormous extension of unsound business, a great commercial crash occurred. The recovery was slow. It was helped by the rapid extension of the railway system in the United States which began in 1871. In 1873 over-speculation and the too sanguine expectations of the American railway builders produced a great financial crisis. The depression spread once more to this country and lasted until 1879 when a succession of good harvests in America caused enterprise once more to raise its head with benefit to the industries on both sides of the Atlantic.

Some Researches on Steam Turbine Nozzle Efficiency*

By HENRY LEWIS GUY, D.Sc., F.R.S., M.I.C.E.

No. III

(*Continued from page 97, Jan. 26th*)

IT would be natural to inquire how far assistance in these important questions of nozzle-efficiency can be obtained by analytical methods. The attack already outlined is purely experimental, and if an analytical basis could be built up not only would design methods be less empirical, but the indication of the theory would make experimental approach more direct and less "hit and miss," and the creature of general instinct and experience.

The problem is obviously vastly more complex than that of the flow around an aerofoil, which has become susceptible to most useful mathematical treatment. The main differences, when contrasted with the aerofoil, lie in the fact that in the case of the nozzle the angle to be turned through is much greater, that compressibility of the fluid not only cannot be neglected but has a dominant effect, and, further, that in the flow through the nozzle passage or across the nozzle-vane, the velocity is continuously increasing and the density continuously decreasing.

It is not surprising, in view of the complexity of the problem, that such analytical approach as has been ventured is, in the final issue, purely empirical and usually more pretentious than useful. I was, however, encouraged some little time ago by Dr. F. W. Lanchester's admirable lecture on skin-friction[5] to see how far the known losses in steam-turbine nozzles could be explained on the basis of skin-friction alone. Earlier and less complete attempts, at a time when nozzles were less efficient, were discouraging because of the great discrepancy between

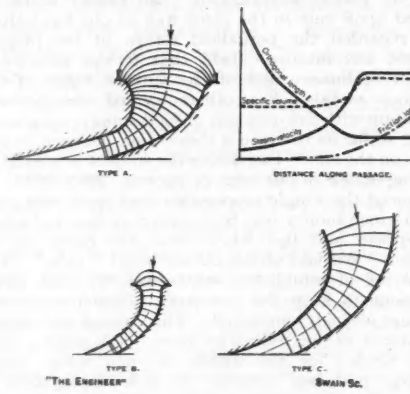


Fig. 27—*Calculation of Skin-Friction Loss*

the calculated losses due to skin-friction and the known or expected total losses in the nozzle.

The most important quantities in such an investigation are the kinematic viscosity of the flowing fluid at various points in its passage, the appropriate co-efficient of skin-friction, the Reynolds number with which to operate, and how it is to be calculated for so variable a passage as that between adjacent nozzle-vanes.

Lanchester published in his lecture a curve of friction coefficients co-ordinated with Reynolds numbers which he deduced from a large number and variety of sources. With weighty and pointed argument he laid down that the Reynolds number should be calculated with a dimension in the direction of flow as the "length" co-ordinate. This for an aerofoil—which is a limiting and simplified use of a nozzle-vane—nominates the "chord" as appropriate.

On the other hand, the flow through a steam-turbine nozzle is a special and complex case of flow through a rectangular channel, and for such flow Messrs. T. E. Stanton's and J. R. Pannell's[6] curves have an importance justified by their value in the solution of many hydraulic problems. The Stanton and Pannel co-ordinates, however, require that the Reynolds number for a pipe—again a limiting and simplified case of a steam-turbine nozzle—shall be calculated with its internal diameter as the "length" term; that is, a dimension at right angles to the direction of flow.

To avoid joining issue with either of these powerful schools, I decided to make calculations by both methods, using in each case the appropriate Reynolds number and friction-coefficient curves.

The result was surprising. Losses in the particular turbine nozzles selected as typical, when using four times the hydraulic mean depth of the passage for the Reynolds number with Stanton's and Pannell's curve, and using the chord of the nozzle-vane with Lanchester's curve, resulted in determinations of total loss in the nozzle passage, which agreed with one another within very close limits. Thus for a nozzle of type C of Fig. 27, the total skin-friction losses calculated with Lanchester's curve was 2·44 per cent., and with Stanton's and Pannell's curve it was 2·50 per cent.

The basis of the method adopted is illustrated in Fig. 27, applied to three types of impulse-turbine steam nozzles, chosen because they were thought to represent in many respects the extremes within which such passages usually range.

The first, type A, is characterised by a very open inlet rapidly converging near the throat to a nearly parallel orifice at that point, whilst the second, B, has an almost parallel but slightly converging passage to the exit. The third nozzle, C, is intermediate between these two, being closely similar to type A in the wide open entry, but differing in the absence of a short length of nearly parallel throat.

For the purpose of calculating the skin-friction loss the passage is split up into a large number of elementary individual passages, bounded by two surfaces on the nozzle-vane a short distance apart in the

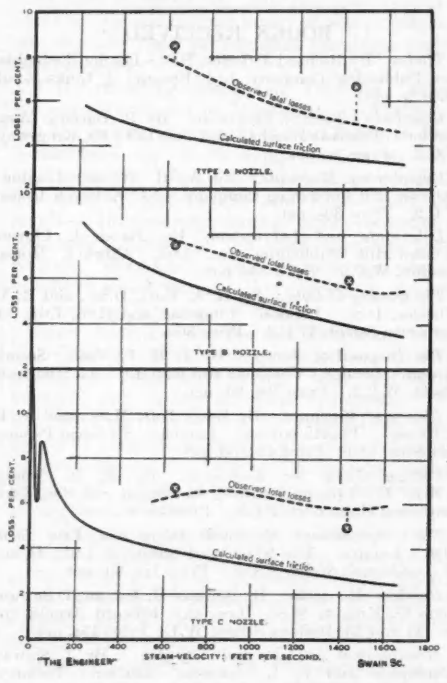


Fig. 28—*Comparison of Measured Loss with Calculated Skin-Friction Loss*

direction of flow, and of such form that they are at all points at right angles to the direction in which flow is judged to be taking place.

From the usual relations governing velocity and area at different points in a nozzle with an expanding fluid such as steam, the velocity and specific volume of the steam can be calculated for each elementary section of the nozzle for any selected set of steam conditions before and after the nozzle.

Fortunately, the co-efficient of skin-friction from Stanton's and Pannell's curve for the first elementary passage at the inlet was found to be almost identical with that for the last element at the throat. For instance, in the case of nozzle A, the two differed by only 3·6 per cent. for an exit velocity of 1675ft. per second, and by 11·4 per cent. for a velocity of 224ft. per second, whereas for nozzle B the differences were 3·7 per cent. and 7·5 per cent. respectively.

Again, for the third nozzle C, intermediate in type between A and B, the difference for an exit velocity of 600ft. per second is 0·1 per cent., and at 1675ft. per second it is 8·6 per cent. by Stanton's and Pannell's methods, whilst the use of Lanchester's curves and Reynolds number gave a larger difference of 22·6 per cent. at the latter velocity.

As will be seen from the shape of the calculated friction-loss curves shown on the right of nozzle A in Fig. 27, the contribution to the total loss of the elementary channels near the throat is so much greater than that of those near the inlet, that with these differences in the correct friction-coefficient between inlet and outlet, no sensible error is introduced by assuming for each element the friction-coefficient determined for the throat elementary passage.

The friction losses calculated in this way with Stanton's and Pannell's curve are given in Fig. 28 for nozzles A and B for steam-velocities ranging from 200 to 1650ft. per second, and for nozzle C with velocities ranging from zero to 1650ft per second. It will be noticed that in both cases the loss-curve slopes steadily downwards as velocity is increased, and this corresponds to a steadily rising velocity-coefficient.

Above this calculated skin-friction-loss curve the losses determined for the same nozzles in the S.N.R.C.-type nozzle-tester are shown in dotted lines. The circled points give the determination of losses by the pitot-tube method, and in spite of this very exacting method of plotting test results they are in good agreement with the nozzle-tester result for nozzles B and C, but whilst in good agreement for nozzle A at the lower velocity, the agreement at the higher velocity is poor.

The skin-friction loss given by such friction-co-efficient curves is a lower limit obtained by very good

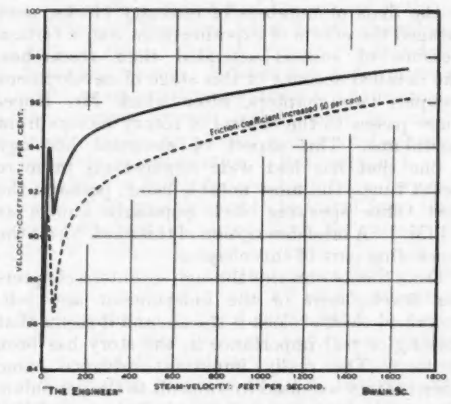


Fig. 29—*Calculated Velocity-Coefficient for Nozzle C, (Fig. 27)*

or ideal forms, as Lanchester strongly emphasised in the case of a form dragged through a fluid. We may expect, therefore, that the skin-friction losses calculated in this way represent a lower limit, to which ideal nozzles may approach. In my considered opinion, any of these forms could be improved by experimental modifications in the neighbourhood of the tail without change in any of the items entering into the skin-friction calculations.

It may reasonably be that the area between the calculated surface-friction-loss curve and the nozzle-test curve represents losses occurring almost wholly beyond the nozzle throat, being associated with "breakaway" and the difficult task of merging the separate streams in individual nozzles at the vane tip into a continuous stream just beyond the exit plane of the nozzle. It should be noted that, in general, the calculated loss-curves have the same kind of slope as the test curves, except for nozzle C, where it

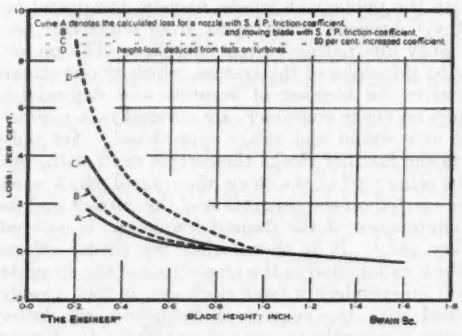

Curve A denotes the calculated loss for a nozzle with S. & P. friction-coefficient
and moving blade with S. & P. friction-coefficient.
" B " " " " " " " "
" C " " " " " " 50 per cent. increased coefficient.
" D " height-loss, deduced from tests on turbines.
LOSS: PER CENT.
"THE ENGINEER"
BLADE HEIGHT: INCH.
SWAIN Sc.

Fig. 30—*Variation of Single-Stage-Turbine Efficiency with Blade-Height*

agrees with the pitot-test indications, if not with that of the S.N.R.C.-type tester.

In order to see how the calculated skin-friction losses based on Stanton's and Pannell's curve varied right down to zero velocity, I have shown in Fig. 28 calculated curves of friction loss from zero velocity to 1700ft. per second. The deep valley at a velocity of about 50ft. per second represents the Stanton's and Pannell's transition curve from streamline to turbulent flow. The velocity-coefficient characteristic which corresponds to this calculated curve for nozzle C is shown in Fig. 29 by a full line. In view of the earlier discussion on the form of nozzle characteristic, it is of interest to note that over the normal range of steam-velocities this calculated curve shows a steadily rising value of the velocity-coefficient with steam-velocity.

I have suggested that the calculated skin-friction losses represent a lower limit to which the losses in an ideal nozzle may approach. The remaining losses probably vary with velocity and kinematic viscosity in much the same way as the skin-friction losses. If this is so, Fig. 28 suggests that all losses may be reasonably approximated by increasing the skin-

* The Sir Charles Parsons Memorial Lecture, 1939.

[5] "The Part Played by Skin-Friction in Aeronautics." Journal Royal Aē. Soc., Vol. xli (1937), p. 68.

[6] "Similarity of Motion in Relation to the Surface Friction of Fluids." Phil. Trans. Roy. Soc. (A), Vol. 214 (1914), p. 199.

friction co-efficient by about from 50 to 60 per cent. to cover these additional sources of loss. In the present state of the art of measuring these losses, such an expedient is by no means so crude as may at first sight appear.

Great caution must be used in treating the losses determined by the nozzle-tester or by other methods of test as having an absolute value instead of a comparative value, because it is doubtful if the absolute accuracy of such methods, even in skilled hands, permits the velocity-coefficient to be determined with greater absolute accuracy than $\pm 0{\cdot}4$ per cent. of its value. Thus, a velocity-coefficient determined by test as 97 per cent. may, in fact, be anywhere between the limits of 96·6 per cent. and 97·4 per cent., which means that the losses may themselves be between the limits of 6·8 per cent. and 5·2 per cent., and that therefore they are determined with an accuracy of only about ± 14 per cent.

Calculations with a friction-coefficient modified in this way justify themselves if they produce useful results by extending experimental determination beyond the range reasonably possible to experiment. For instance, to take a simple case, it is known that, in a turbine, as the height of the nozzle and the blade beyond it are decreased the efficiency of the combination decreases fairly definitely for heights below, say, 1in. By similar methods the surface-friction losses in both nozzle and moving blade can be calculated for the same sections but with decreasing heights.

The results of such calculations are given in Fig. 30 for a particular nozzle and moving-blade combination, for which the loss of efficiency deduced from turbine test is given in the top curve. The fact that the expected increase in loss as height is reduced is greater than that calculated with the surface-friction coefficient increased 50 per cent., is in accordance with expectation, because there are other known losses in such a combination of nozzle and moving blades, such as spilling, induction of inert surrounding steam, splitting of the stream, and disk-friction and windage of shrouding, which may be quantitatively indicated by the difference between the two curves.

A more important use of such calculation arises if it can give some indication of the variation in efficiency of nozzles and blading to be expected with changes in steam-pressure and temperature. In this matter even a rough indication would have a great utility, because the variation in efficiency of a nozzle and moving blade with pressure and temperature over the full range now employed in practice, cannot be obtained even qualitatively by direct experiment on individual nozzles or blades.

TABLE III.—*Values of Absolute and Kinematic Viscosity for Steam*

Pressure : lb. per square inch absolute.	Temperature : deg. Fah.	Specific volume : cubic ft. per lb.	Absolute viscosity : lb.-sec. per square foot.		Kinematic viscosity : square feet per second.		Ratio to water.	
			Hawkins, Solberg, and Potter.	Sigwart.	Hawkins, Solberg, and Potter.	Sigwart.	Hawkins, Solberg, and Potter.	Sigwart.
14·7	650	44·54	$0{\cdot}460\times10^{-6}$	$0{\cdot}451\times10^{-6}$	$6{\cdot}6\times10^{-4}$	$6{\cdot}45\times10^{-4}$	54·7	53·5
14·7	850	52·62	$0{\cdot}540\times10^{-6}$	$0{\cdot}498\times10^{-6}$	$9{\cdot}14\times10^{-4}$	$8{\cdot}43\times10^{-4}$	—	—
14·7	1000	—	$0{\cdot}60\times10^{-6}$	$0{\cdot}498\times10^{-6}$	—	—	—	—
250	650	2·558	$0{\cdot}560\times10^{-6}$	$0{\cdot}454\times10^{-6}$	$0{\cdot}46\times10^{-4}$	$0{\cdot}374\times10^{-4}$	3·8	3·1
250	850	3·067	$0{\cdot}640\times10^{-6}$	$0{\cdot}500\times10^{-6}$	$0{\cdot}631\times10^{-4}$	$0{\cdot}494\times10^{-4}$	—	—
250	1000	3·438	$0{\cdot}720\times10^{-6}$	$0{\cdot}500\times10^{-6}$	$0{\cdot}797\times10^{-4}$	$0{\cdot}533\times10^{-4}$	—	—
2000	650	0·210	$1{\cdot}227\times10^{-6}$	$0{\cdot}490\times10^{-6}$	$0{\cdot}083\times10^{-4}$	$0{\cdot}033\times10^{-4}$	—	—
2000	850	0·337	$1{\cdot}289\times10^{-6}$	$0{\cdot}512\times10^{-6}$	$0{\cdot}140\times10^{-4}$	$0{\cdot}055\times10^{-4}$	—	—
2000	1000	0·399	$1{\cdot}353\times10^{-6}$	$0{\cdot}512\times10^{-6}$	$0{\cdot}174\times10^{-4}$	$0{\cdot}0657\times10^{-4}$	1·45	0·545
29in. vacuum	78·9	653	—	$0{\cdot}211\times10^{-6}$	—	$44{\cdot}3\times10^{-4}$	—	368

NOTE: { For air, at 60 deg. Fah. and 30in. of mercury, the kinematic viscosity = $1{\cdot}565\times10^{-4}$ square feet per second
For water at 60 deg. Fah. and 30in. of mercury, the kinematic viscosity = $0{\cdot}1205\times10^{-4}$ square feet per second

Some attempt was made in this direction [illegible] an extremely narrow range by the S.N.R.C. They advisedly put forward the results with considerable caution. Further, the results obtained were anomalous and discordant in themselves, and differ materially from the deductions from tests on full-scale turbines within that range of variation.

If the variations of efficiency with pressure and temperature are to be calculated, the most important quantity required is the change in viscosity of steam with pressure and temperature over such a wide range as from 2000 lb. per square inch and 1000 deg. Fah. to 29in. of vacuum, or 79 deg. Fah.

Two recent researches have been made in this matter, one by K. Sigwart in Germany, using the flow through a fine-bore tube,[7] and the other by Messrs. G. A. Hawkins, H. L. Solberg, and A. A. Potter in the United States, by observing the time taken for a plug to drop a known distance in a closely fitting tube.[8] Whilst the viscosity determinations of both agree very well at low pressures and temperatures, they differ widely at the high steam-pressures and temperatures which are now of interest and importance in steam-turbine work. Certain values are given in Table III from which it will be noticed that at a pressure of 2000 lb. per square inch and a temperature of 1000 deg. Fah., Hawkins's, Solberg's, and Potter's value for the kinematic viscosity is 2·65 times that of Sigwart's.

It is of interest to recall that in connection with the problems of flight, Lanchester long ago pointed out that the kinematic viscosity of air was nearly 13 times that of water, and has suggested that the implications of this difference were for long unappreciated. I wonder whether it is generally appreciated that the kinematic viscosity of steam at the condition of atmospheric exhaust and 330 deg. Fah. usually employed in nozzle-testing is about 26 times that of water, and double that of air. Neither do I think it is appreciated that at a 29-in. vacuum—the usual pressure at exhaust from the last turbine stage—the kinematic viscosity of steam is 368 times that of water. Again, according to Sigwart's determinations, the kinematic viscosity of steam at 2000 lb. per square inch and 1000 deg. Fah. is only about one-fiftieth of that of steam at the atmospheric exhaust pressure and 330 deg. Fah. temperature usually employed in nozzle-tests. Hawkins, Solberg, and Potter would make the ratio about 1/20.

Both researches, however, agree that the kinematic viscosity of steam at a 29-in. vacuum is over 14 times greater than that at which nozzle tests are usually made.

Table IV summarises surface-friction calculations for the three nozzles A, B, and C for both 600ft. per second and sound-velocity at exit, and for the steam-conditions usual in nozzle testing, in contrast with steam-conditions of 2000 lb. per square inch and 1000 deg. Fah. before the nozzle and for vacua of 27in. and 29in. of mercury at the outlet. The calculations are made with Stanton's and Pannell's friction-coefficients, and both for Sigwart's values for viscosity and for those of Hawkins, Solberg, and Potter. The resulting values of the difference of the calculated losses for the two sets of viscosity-determinations do not differ greatly.

Averaging the whole Table for the three types of nozzles and for sound-velocity at exit, the calculated improvement to be expected in nozzle-efficiency at about 2000 lb. per square inch and 1000 deg. Fah. is almost exactly 1½ per cent. If we assume that the losses other than surface friction varied with steam-pressure and temperature in the same way as surface friction, and can be included by increasing the surface friction by one-half, then with sound-velocity at exit a nozzle should be 2¼ per cent. more efficient at 2000 lb. per square inch and 1000 deg. Fah. than at 27·8 lb. per square inch and 450 deg. Fah. at inlet.

Now consider the positions at the lower exit-velocity of 600ft. per second. Considering surface-friction losses alone and averaging the Table for the three types of nozzles, the efficiency at inlet-conditions of 2000 lb. per square inch and 1000 deg. Fah. would be almost exactly 2·3 per cent. better than with 15·7 lb. per square inch and 450 deg. Fah. at inlet. If, however, the remaining losses can be included by increasing the friction-coefficient by one-half, then

TABLE IV.—*Friction Loss in Nozzles at Various Velocities, Pressures, and Temperatures.*

		Case.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1		Exit velocity	Critical						600ft. per second						Critical			
2		Exit velocity : feet per second	1670	2040	1670	2040	1670	2040	600		600		600		1670	1395	1670	1450
3		Section	A		B		C		A		B		C		A			
4		Inlet conditions: Pressure : lb. per square inch	27·8	2000	27·8	2000	27·8	2000	15·7	2000	15·7	2000	15·7	2000	27·8	28·16 in. vacuum	27·8	24·53 in. vacuum
5		Inlet conditions: Temperature : deg. Fah.	450	1000	450	1000	450	1000	450	1000	450	1000	450	1000	450	160	450	264
6		Outlet conditions: Pressure : lb. per square inch	14·7	1090	14·7	1090	14·7	1090	14·7	1920	14·7	1920	14·7	1920	14·7	29 in. vacuum, dry	14·7	27 in. vacuum
7		Outlet conditions: Temperature : deg. Fah.	330	811	330	811	330	811	435	982	435	982	435	982	330	78·9	330	114·9
8		Specific volume of inlet (1939, Callendar) : cubic feet per lb.	19·36	0·394	19·36	0·394	19·36	0·394	34·38	0·394	34·38	0·394	34·38	0·394	19·36	407	19·36	152·3
9		Specific volume of outlet (1939, Callendar) : cubic feet per lb.	31·78	0·632	31·78	0·632	31·78	0·632	36·13	0·405	36·12	0·405	36·12	0·405	31·78	656	31·78	232·5
10	Absolute viscosity (Sigwart)	Absolute viscosity at outlet : lb.-seconds per square foot $\times 10^7$	3·19	5·05	3·19	5·05	3·19	5·05	3·51	5·12	3·51	5·12	3·51	5·12	3·19	2·11	3·19	2·27
11	Absolute viscosity (Sigwart)	Kinematic viscosity at outlet : square feet per second $\times 10^3$	31·9	1·04	31·9	1·04	31·9	1·04	40·8	0·676	40·8	0·676	40·8	0·676	31·9	443	31·9	170
12	Absolute viscosity (Sigwart)	Reynolds number (Stanton and Pannell)	251,000	9,390,000	130,800	4,890,000	174,000	6,500,000	704,000	4,250,000	36,600	2,210,000	48,700	2,940,000	251,000	14,950	251,000	40,800
13	Absolute viscosity (Sigwart)	Friction coefficient (Stanton and Pannell)	0·0152	0·0094	0·017	0·010	0·0162	0·0097	0·0194	0·0101	0·0225	0·0109	0·021	0·0106	0·0152	0·0288	0·0152	0·022
14	Absolute viscosity (Sigwart)	Total friction loss : per cent.	3·100	1·783	3·436	1·68	2·507	1·154	4·48	2·331	6·15	2·981	4·12	2·078	3·10	6·14	3·10	4·64
15	Absolute viscosity (Sigwart)	Difference in total friction loss : per cent.	−1·317		−1·756		−1·353		−2·149		−3·169		−2·042		+3·04		+1·54	
16	Absolute viscosity (Trans. Am. Soc. M.E.)	Absolute viscosity at outlet : lb.-seconds per square foot $\times 10^7$	3·2	9·3	3·2	9·3	3·2	9·3	3·5	13·2	3·5	13·2	3·5	13·2	—	—	—	—
17	Absolute viscosity (Trans. Am. Soc. M.E.)	Kinematic viscosity at outlet : square feet per second $\times 10^5$	—	1·915	—	1·915	—	1·915	—	1·74	—	1·74	—	1·74	—	—	—	—
18	Absolute viscosity (Trans. Am. Soc. M.E.)	Reynolds number (Stanton and Pannell)	—	17,300,000	—	9,010,000	—	12,000,000	..	1,650,000	—	860,000	—	1,140,000	—	—	—	—
19	Absolute viscosity (Trans. Am. Soc. M.E.)	Friction coefficient (Stanton and Pannell)	—	0·0088	—	0·0094	—	0·0092	—	0·0113	—	0·0123	—	0·0118	—	—	—	—
20	Absolute viscosity (Trans. Am. Soc. M.E.)	Total friction loss : per cent.	3·10	1·737	3·436	1·62	2·502	1·131	4·48	2·608	6·15	3·361	4·12	2·314	—	—	—	—
21	Absolute viscosity (Trans. Am. Soc. M.E.)	Difference in total friction loss : per cent.	−1·363		−1·816		−1·371		−1·872		−2·789		−1·806		—		—	

[7] "Messungen der Zähigkeit von Wasser und Wasserdampf bis ins kritische Gebiet." Forschung auf dem Gebiete des Ingenieurwesens, Vol. 7 (1936), p. 139.

[8] "The Viscosity of Water and Superheated Steam." Trans. Am. Soc. M.E., Vol. 57 (1935), p. 395.

the improvement in nozzle-efficiency at the higher condition is increased to nearly 3·5 per cent.

These are significant and important conclusions, which may play a part in the ultimate development towards extreme steam-conditions.

We can also, in the same way, arrive at an estimate of the decrease in nozzle-efficiency for the steam-conditions in the last stage of a turbine exhausting at 29in. vacuum, as compared with the usual atmospheric exhaust of nozzle tests.

In this case, nozzles A most nearly represent the type of nozzles which would be used, and the exit velocity would be about equal to that of sound. For this nozzle we deduce that, with Stanton's and Pannell's co-efficients and for skin-friction alone, the efficiency of the nozzle in the last stage will be almost exactly 3 per cent. worse than that deduced from the nozzle-test inlet-conditions of 27·8 lb. per square inch and 450 deg. Fah. Further, this loss in efficiency is increased to 4·5 per cent. if the remaining nozzle-losses can be represented by a 50-per-cent. increase in friction-coefficient.

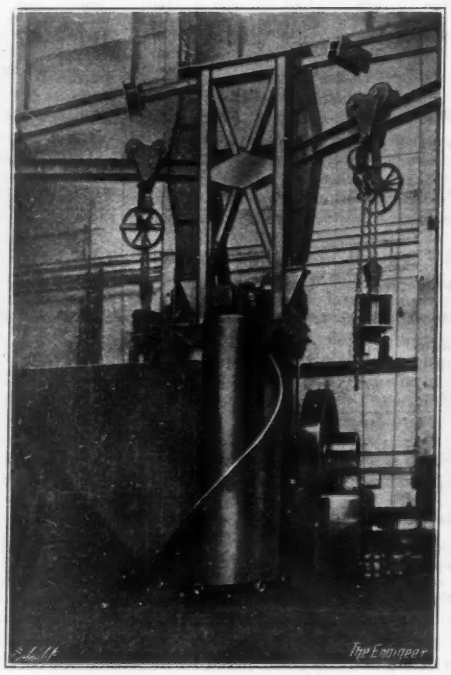
The presence of this considerable loss in the low-pressure end of a turbine has probably been overlooked because the improvement in the efficiency of the nozzles in that end of the machine, due to the greater angles of efflux of the nozzles there employed (exhibited in Figs. 25 and 26), has also been insufficiently appreciated.

Again, Table IV shows that, compared with the atmospheric exhaust of nozzle-experiments, whilst the increase in calculated surface-friction loss, with friction-coefficients increased 50 per cent. to cover all losses, would be 4·5 per cent. when exhausting to a 29-in. vacuum, it would only be 2·31 per cent. for a 27-in. vacuum. Thus the increase in kinematic viscosity results in a decrease in nozzle-efficiency of 2·25 per cent. for these 2in. of vacuum, a fact which has, I believe, been ignored in the calculation of vacuum corrections.

I cannot conclude without acknowledging my great indebtedness to all those with whom I have worked and who have worked with me on this subject, and in particular to Mr. K. Baumann, Mr. N. Elce, M.Sc., Mr. J. R. Finniecome, Mr. B. Hodkinson, M.Sc., Assoc. M.I.C.E., Mr. C. G. Lloyd, and Mr. R. Poole, Assoc. M.I.C.E.

Etzel Welded High Pressure Pipeline, Switzerland

AN interesting all welded high pressure pipeline for the electric power plant at Etzel, in the canton of Schwytz, has recently been completed by Sulzer Brothers, Ltd., of Winterthur. The power plant uses a fall of 483·3 metres in the Sihl river, and the pipeline conveys water from a reservoir formed in what was formerly a marshy valley, a little over five kilometres to the power station. From this artificial lake, a pressure gallery 2940 metres long has been



FORMING A PIPE SECTION

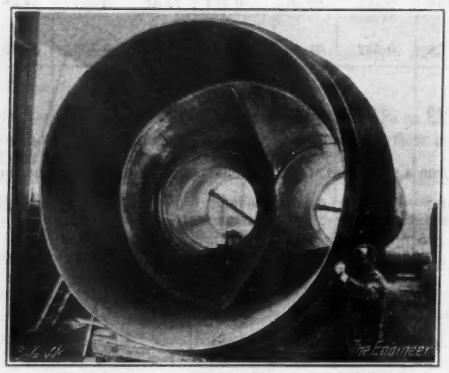
built, ending in a surge tank from which the high pressure pipeline, 2200 metres long, runs down to the plant. The catchment area of the lake is about 156 square kilometres, and its useful capacity about 91,600,000 cubic metres. The power house, when the six 20,000 H.P. turbines have all been installed, will use about 32 cubic metres of water per second.

At the south end, the lake is bounded by a dam 800 metres long, and trenches have been cut to bring in water from regions beyond the dam. On the west, a flat depression is closed by a second dam, built principally of gravel, 73 metres thick and 15 metres maximum height. A third dam in masonry is provided at the north, and it is in this structure that the inlet pipe for the pressure gallery is situated. This inlet is protected by an iron grating allowing a clearance of 30 mm. between the bars, and it can be closed by sluice gates to cut off the flow of water. The diameter of the inlet pipe is 3000 mm. and its length is 50 metres. It is provided with a throttle valve and divides into three branches. One, consisting of two parallel 500 mm. diameter pipes, runs up through the dam to a point above the highest water level and serves to vent the pressure gallery. A second branch consists of an 1800 mm. diameter pipe, capable of accommodating a flow of 20 cubic metres per second, and is used for occasional flushings

COMPLETED SECTION OF PIPELINE

of the bed of the Sihl river. To compensate for the weakening caused by the introduction of this large diameter pipe the patented Sulzer collar stiffening construction was adopted. The third branch, used to provide a normal flow of water to the Sihl, affords passage for a normal minimum flow of 2·5 cubic metres of water. The pressure gallery into which this outlet pipe opens presents no special peculiarities.

From the surge tank, in which the pressure gallery ends, two high pressure pipes of 2100 mm. diameter each run to the power plant. These two pipes are connected to a 3000 mm. diameter breeches pipe. As the two pressure pipes approach the power plant, their inside diameters decrease progressively by steps of 50 mm. from the original 2100 mm. to 1800 mm., which is reached at the distribution pipe at the power house. At this lower end, the two pipes separate, one entering the distribution pipe at either



BREECHES PIPE

end of a loop which this latter forms, around both sides of the power house. This distribution pipe, 1800 mm. diameter at its junction with the high pressure pipes, decreases first to 1500 mm. and then to 1200 mm. diameter. From it 16 branches formed of 750 mm. piping run to the turbines. Static pressure of the water at the surge tank is 3·5 atm., while at the connection of the high pressure pipes with the distribution loop it reaches 48 atm.

The high pressure pipes, breeches pipe, distributing loop and branches are all of welded construction. The upper part of the high pressure pipes is made from Siemens Martin mild steel plates, varying in thickness from 17 mm. at the top to 36 mm. at the lower end of this section. The tensile strength increases from 35 kg. to 41 kg. per square millimetre, while the minimum elongation is uniformly 25 per cent. For the lower part of the high pressure pipeline mild steel plate has been used, which is rather unusual. Thickness varies from 31 mm. to 45 mm. and tensile strength from 41 kg. to 47 kg. per square millimetre. Elongation is uniformly 23 per cent.

Another peculiarity of the pipes used on this lower section is that the seam, instead of being longitudinal, is spiral. Plate thicknesses are calculated to withstand a pressure of 10 per cent. above the static pressure of water at any given point. Normal longitudinally seamed pipes must be considered as presenting a weld having a strength of 85 per cent. of that of the full plate. This means that with such a pipe, the permissible circumferential stress is 900 kg./cm.² for MI steel, or 1050 kg./cm.² for MII steel. Experiments have shown, according to the makers, that by using a spiral seam the weakness of the weld relative to the full plate ceases to exist, so that the pipe may be considered as having the resistance of a seamless pipe, giving 1060 kg./cm.² for MI steel and 1230 kg./cm.² for MII steel.

The pipe sections were made up on special bending machines from rhomboidal plates, rolled into tubular shape, and were then welded to form the seam. For pipes of sheet up to 19 mm. thick a single vee-butt weld was used, whereas for thicker pipes double vee-butt welds were preferred. The men engaged in the welding had to proceed with great care, as the least defect under the pressures reached in service could provoke an accident. After welding, pipes with wall thicknesses of 24 mm. or more were annealed at a temperature of 600 deg. Cent. in order to remove any internal stresses that might have been introduced by the welding. Each pipe section was then tested under hydraulic pressure to 1·5 times the normal service pressure, to detect any defects.

Successive lengths of pipe were assembled on the job, Sulzer muff testing joints being used throughout. For pipes in plate up to 23 mm. thick, the muffs were formed on the bending machine during the forming of the pipe section, but for pipes of thicker plate, the muffs were machined on a lathe. Each joint was tested immediately on completion. The pipe sections were not painted before being sent out from the factory. Instead, they were sandblasted clean on the job, and immediately covered with a priming coat of special oil. After erection, they were then covered with a bandage of jute soaked in hot bitumen. Work on the assembly of the pipeline

ERECTION OF PIPELINE

was carried out simultaneously from two points, five welding machines being used at each point. Current for their operation was provided by a power line erected parallel with the pipeline.

The supply of the pipes and the general contract for their erection were entrusted to Sulzer Brothers, Ltd. Part of the work on the upper end of the erection was subcontracted, but the firm provided all the material, and executed the lower end of the erection work as well as overseeing the whole job. A number of photographs are reproduced herewith to illustrate the work.

PROPOSED AMERICAN SUPER-HIGHWAY.—What is termed a super-highway has been proposed by representatives of eight eastern states of the United States. It will be 400 miles long, have six traffic lanes, and its estimated cost is 200 million dollars. Reports say that officials of Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Pennsylvania, and Maryland have agreed to prepare detailed plans for submission to the next session of Congress.

Synthetic Materials for Mill Bearings*

THE laminated material used in bearings is made up of two parts, the bonding material, which is phenol-formaldehyde resinoid, and the filler, which is a woven cotton cloth. The cotton cloth is treated with the resinoid and many layers are consolidated into a solid mass under heat and pressure. The material is now hard, infusible, insoluble, stable, and very non-hygroscopic, although it does absorb a very small percentage of water on its surface only.

The specific gravity of the material is 1·35. It therefore fills the gap between wood and the light metal alloys. The tensile strength across the face in two directions is between 4 and 5 tons per square inch, and through the thickness of the board, about 2 tons. The tensile strength can be partly controlled by the arrangement of the reinforcing fibres, and if desired considerably higher strength can be obtained in one particular direction. The shear stress through the laminations is between 4 and 5 tons per square inch, while its compressive stress flatwise is somewhere near 18 tons on a 1in. cube. In many cases, such as in aircraft, strength alone is not the most important factor, and when judged on a strength per weight ratio basis synthetic resin materials compare favourably with other materials. The Brinell hardness, using a load of 125 kgm. on a 5 mm. ball is between 33 and 37. It is difficult to assess a true hardness value as the impression of the ball may be taken in a variety of positions relatively to the weave of the filler and this gives rise to large variations in the results obtained. The Brinell hardness, so far as it is yet known, is not considered a criterion of the properties required for bearings. The thermal conductivity is very poor and the material can almost be classed as a heat insulator. Its co-efficient of thermal expansion differs along the laminæ and through the laminæ; through the laminæ it is ·00006in. to ·00008in. per deg. Cent., while along the laminæ it is ·00004in. per deg. Cent.

The figures given above do not cover all grades of phenolic laminated material. In other grades strengths up to 15 tons per square inch can be obtained, accompanied by changes in other properties. In the case of metals it is known that there is a definite relationship between tensile strength and shear, but no such relation has as yet been established in the case of synthetic resin materials. The modulus of elasticity differs in tension and compression and the material has a very pronounced hysteresis loop under stress, with a very slow time recovery. The stress-strain curve lacks the well defined yield point of metals and does not appear to follow Hook's law, bending away from a true elastic curve almost at the origin, but maintaining a firm curve right up to the breaking point. Different values of the modulus E are obtained by different rates of loading. Fig. 1 shows typical stress-strain curves for a paper base phenol formaldehyde resin is a completely amorphous material and appears to be just a middled pattern of macro molecules; it has no definite arrangement or regular plan, such as is found in natural materials. There have been numerous investigations which point to this amorphous material being an "isogel," held together by two kinds of bonds: the primary chemical bonds holding the molecules together, and secondary bonds, called "Van der Waals" forces, which are cohesive forces, which can hold molecules

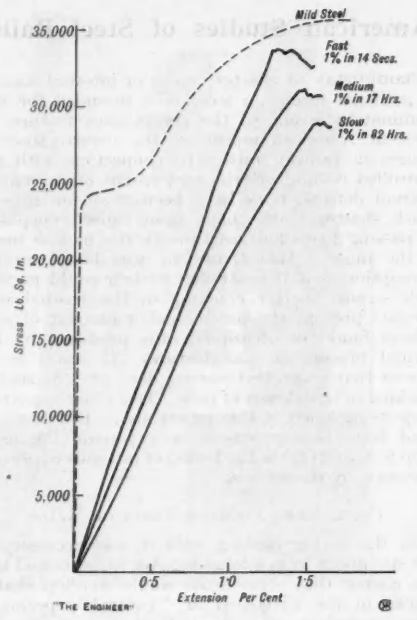


FIG. 1—STRESS-STRAIN CURVES FOR PAPER BASE MATERIAL

together where there is no actual chemical combination. J. H. de Boer has shown that a large discrepancy exists between the theoretical tensile strength calculated on primary or secondary bonds only and the experimental figures obtained. In practice, we only get some 5 per cent. of the theoretical strength. This discrepancy between the theoretical and experimental tensile strength is quite general and is not confined to resins. It is also found in glass, metals, and crystals, and it has been suggested by A. A. Griffith that it is due to long, thin, submicroscopic cracks causing local concentrations of stress far above the mean value. Houwink has discussed the possible existence of such intramolecular "cracks" in synthetic resins. They are probably caused by the loose ends of molecules which have not been tied up during the formation of the three dimensional structure.

A considerable increase in strength is observed in metals when the grain flow is controlled along desired lines, and in similar fashion if we could orientate the molecules in synthetic resins, and ensure continuity of linkage, we should be able greatly to improve the mechanical properties. Many of these questions are receiving further investigation, and no doubt many new factors will come to light as time goes on. It must be remembered, however, that these synthetic plastic materials have only been in use about 30 years, so that we still have a long way to go to catch up with the present-day knowledge of metals which has some 5000 years experience behind it. This new material is still in the cradle, but it shows promise of growing into one of the giants of the age.

Laminated plastic material, or rather "synthetic resin bonded laminated sheet," to give it its full title, has been applied to the problem of bearings for the past ten years with considerable success. It must not be thought that it can be looked upon as a universal cure for all evils and be applied indiscriminately. It has certain limitations, and to obtain the benefit of the advantages that it offers special consideration must be given to each particular application.

Let us consider then some points that can be placed in favour of laminated plastine material for bearings:—

(1) The material is light and can be easily handled. (2) Has the requisite strength. (3) Smooth bearing surface. (4) Good load-carrying capacity. (5) High resistance to impact. (6) Can be lubricated by any medium. (7) Non-scoring properties. (8) Low co-efficient of friction. (9) Low thermal conductivity. (10) Low modulus of elasticity minimising high concentration of load. (11) Hard wearing.

On the economics side the advantages are:—(12) Higher output. (13) Saving of power. (14) Lower lubrication costs. (15) Reduced maintenance costs. (16) Longer life, &c.

Its disadvantages include:—(17) Poor heat conductor. (18) Low temperature range of operation. (19) Experience of operators. (20) Initial cost of application. (21) No scrap value. (22) Not of universal application.

The largest application of the material to bearings has been in rolling mill plant, although much success has been achieved in other spheres. The material has found its way into ball and roller bearings where the cages are made of plastic materials for special high speed jobs—see Fig. 2 The advantages and disadvantages of the material for use in mill bearings may, in the light of experience gained from several applications, be summarised as follows:—

The weight of the material being only approximately one fifth that of metals, there is no need to enlarge upon its lightness. It can be easily machined by standard methods.

Experience has shown that the material has all the strength necessary for a good bearing material. It does not age harden, soften under heat, or flow to any extent under excessive loads. When first tried, complete bearings were cut from the solid and splitting was experienced along the laminæ, but it has since been found, from an economical as well as a practical point of view, that it is better to line a bearing with strips, or with a complete lining—see Fig. 3—and retain the metal housing.

The bearing material can be brought to a high surface finish, and if the neck and thrust faces of the journal are ground and polished before fitting synthetic resin bearings the bearings will act as a polishing pad and keep the bearing surfaces in good condition. Any roughness or surface irregularities on a journal are likely to cause a considerable amount of wear in the bearing.

The load carrying capacity is generally higher than

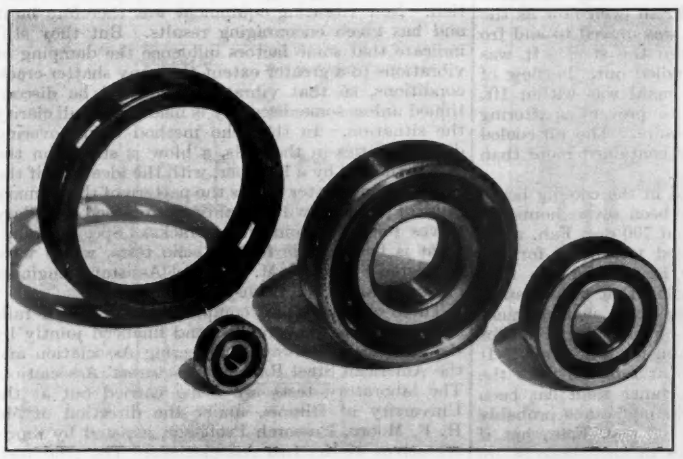


FIG. 2—BEARINGS WITH CAGES MADE OF PLASTIC MATERIAL

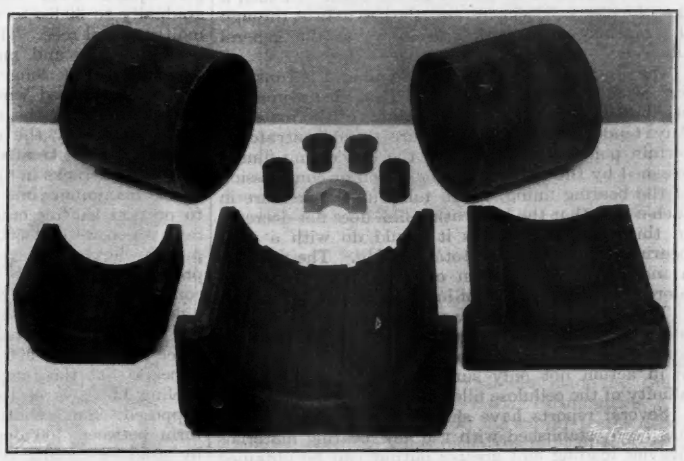


FIG. 3—BEARINGS OF PLASTIC MATERIALS

material. With the scanty information at present available, no account can be given of the plastic or elastic deformation of the material under stress. It has considerable power of recovery, which is greatly accelerated by gently heating the specimen.

The material has a high degree of resistance to chemical attack and is unaffected by dilute acids or alkalies. It is slightly attacked by strong caustic soda and pure alcohol, but is impervious to all weather conditions. Prolonged heat or intense cold will not change the physical properties of the material once it has reached the final hardened or "C" stage. The reaction between phenol and formaldehyde has not yet been fully elucidated. From X-ray analysis it has been deduced that the that of metals. H. Rochester has suggested the following sub-divisions.

Loads

Light:	All pressures up to 500 lb. per square inch.
Medium:	All pressures from 500 lb. to 1500 lb. per square inch.
Extra heavy:	All pressures over 4000 lb. per square inch.

Rubbing Speed with Water as Lubricant

Light loads:	100ft. to 4000ft. per minute.
Medium loads:	150ft. to 3000ft. per minute.
Heavy loads:	250ft. to 2500ft. per minute.

Extra heavy loads require grease or sub-oil with water.

Not only is the material capable of maintaining these high loads but the machine may also be stopped

* From a paper presented before the Midland Metallurgical Societies by Mr. C. D. Philippe.

and restarted under load without fear of seizure or scoring of the journal. In one particular application, a stainless steel cold rolling mill, it was found that narrower limits of the rolled strip could be maintained and if variation did occur the machine could be stopped, adjusted, and restarted without trouble. If this procedure had been attempted before the introduction of plastic bearings the machine would have been almost torn from its foundations and heavy scoring of the journal would have occurred. The lubrication of the plastic bearing was by a water soluble oil forced under pressure through the bearing on to the journal. While rolling the biggest step the pressure in the journal neck was estimated at over 5000 lb. per square inch, the strips produced being ·008in. thick, to limits of ±·0001in.

Because of the high resistance to impact, creeping or flowing, such as occurs in Babbitt and other bearings under the hammer action of work entering the rolls, does not take place with phenolic laminated bearings. An empirical test carried out clearly shows up this property. Several pieces of different material —2in. square by ·675in. thick—were placed on a solid floor. A flat nosed tool was fitted to a pneumatic road drill and the squares pounded in turn for ¼ minutes. All the discs shows a considerable amount of flow and distortion, except the two fabric base plastic materials, one of which, an inferior grade, blistered due to the heat generated by the pounding, while the other showed no ill effects of its harsh treatment.

Lubrication cannot be dismissed as something unimportant, for, while it can be claimed that water provides sufficient lubrication and that a bearing can and will run dry satisfactorily, these claims are true only under special circumstances. For the best results, due consideration must be given to the question of lubrication. The lubricant acts very largely in the capacity of a coolant, but even if the lubrication supply should fail, seizure or scoring does not take place, even although the temperature rises to the point causing charring of the bearing.

Different investigators quote different figures for co-efficients of friction, which vary considerably under different conditions, but using water lubrication, a mean figure of ·0035 may be taken for all loads between 1000 lb. and 4000 lb. per square inch, and rubbing speeds between 500ft. and 3500 ft. per minute.

The low thermal conductivity appears both on the credit and debit side. At first sight it would seem to be entirely detrimental, as many machines rely upon the heat generated in the bearings being dissipated through the bearing housings and frame work. Because of the low conductivity, special attention must be given to the elimination of the heat of friction, particularly where the rolls must be kept at an even temperature, such as in cold rolling mills. This cooling function is generally performed by the lubricant, although in some cases a plastic bush is fitted in the journal and rotates with the roller so acting as an insulator to heat being passed to the roll body. There is at least one case where the low conductivity is an asset, namely, when the rollers are required to be maintained at a special temperature, for instance, in rubber masticating mills where heat has to be applied internally to the rolls. In such a case the plastic bearing retards the loss of heat through the machine framework and improves the general efficiency.

The co-efficient of friction is small and is constant for widely varying speeds. This behaviour is attributed to the low elastic modulus of the material. Any tendency for high pressure to concentrate at certain points and so destroy the lubricating film is lessened by the appreciable deflection or compression of the bearing lining, which takes up the pressure in such a way that the lubricating film does not decrease in thickness as much as it would do with a rigid bearing under the same total loading. The result is a more even distribution of pressure and hence a more uniform thickness of lubricating film.

The so called hard wearing properties of the material may be due to its ability to hold on its surface a much heavier film of water than metal, since there is in action not only surface tension but also the affinity of the cellulose filler for water as well.

Several reports have shown that once confidence has been established with the new bearing materials heavier loading and greater output can be obtained while a saving of 25–30 per cent. in the power consumption is not uncommon. With water only as a lubricant the shut-down periods are less frequent, and maintenance costs much less.

There are, as already indicated, several limitations which must be taken into consideration. The poor heat conductivity necessitates an adequate supply of cooling media; with standard cotton-filled materials this must be sufficient to maintain the temperature on the bearing surface below 300 deg. Fah. Newer materials have shown that an operating temperature of 750 deg. Fah. may be possible, but they have not yet been tested for such applications as bearings. Lack of experience in operating machinery with plastic material bearings may give rise to an adverse opinion of their value. The mechanic or operator must get to know the "feel of tightness" of the bearing. If screwed down too tight or not fitted correctly in the first place, excessive wear may be experienced. When compared, weight for weight, with metals, the cost of the material is high, and there is no scrap value since it cannot be reworked and used again. It is, therefore, important to give careful consideration to the initial application to ensure success.

It is claimed that 80 per cent. of the rolling mills in Germany are fitted with plastic material bearings and there are many successful applications now operating in this country. As has already been said, these materials have not a universal application for bearings, nor must it be thought from some glowing accounts that they have become the universal "cure-all" for all bearing shortcomings. The material should not be looked upon as merely a substitute for metals. It is a new material with an individuality of its own, having certain advantages and certain limitations when compared with other materials.

American Studies of Steel Rails

PRODUCTION of shatter cracks or internal fissures by artificial means in steel rails intended for test examination is one of the conspicuous features of a recent American report on the investigation of fissures in railway rails. In connection with the controlled cooling of rails as a means of preventing internal defects, tests have been made on rails in which shatter cracks have been caused purposely by passing hydrogen gas through the molten metal in the ingot. This treatment was based on the assumption that if controlled cooling could prevent such serious shatter cracking in the treated rails it could prevent the much smaller amount of such defects found in occasional rails produced by the normal process of manufacture. It seems to be proved that controlled cooling does prevent shatter cracking in both kinds of rails. Two other important subjects included in this report are: (1) The use of bend tests to supplement or supersede the usual drop test, and (2) the hardening of rail ends to prevent battering by the wheels.

CONTROLLED COOLING TESTS OF RAILS

In the earlier cooling tests it was necessary to use specimens from a large number of heats and take the chance that some heats would develop shatter cracks in the air-cooled or "control" specimens. This procedure was unsatisfactory owing to the time and expense involved. Treating the ingots with hydrogen in order to cause a large number of shatter cracks has proved of great assistance, since all the specimens from such ingots have developed a large number of these defects during cooling in the open air. The ingot moulds were 8½ft. high, holding 5 tons of steel, and one ingot from a heat was given the treatment. Hydrogen from a compressed gas cylinder was bubbled through mercury in a glass bottle so as to indicate when the gas was flowing. From the stopper a rubber hose was connected with the end of a ¼in. steel pipe, part of which was bent to stand vertically in the ingot mould, reaching nearly to the bottom. The escaping hydrogen was lighted before starting to pour the ingot, and the initial pressure was about 15 lb. per square inch, this pressure being increased gradually to 30 lb. to maintain an even flow as the molten metal rose. The pipe was moved to and fro in the mould, and melted into the steel. It was from 2ft. to 4ft. long when pulled out, the flow of gas being stopped when the metal was within 1ft. from the top of the mould, to prevent spattering of the metal by the gas pressure. The air-cooled specimens from treated ingots contained more than 100 shatter cracks in 6in. slices.

The maximum time required in the cooling boxes to prevent shatter cracks has been seven hours for rails which were at 500 deg. and 700 deg. Fah. when put in the boxes. A proposed treatment for the prevention of shatter cracks is to hold the rails constantly at a temperature below that which causes a decrease in hardness. In these tests, shatter cracks did not develop in rails held at 1100 deg. Fah. for three hours or at 900 deg. Fah. for four hours. It appears that the temperature at removal from the cooling boxes is of less importance than has been supposed. Some shatter cracks or fissures probably form between 400 deg. and 300 deg. Fah., but if by gradual cooling the causes of such defects are removed, then the defects will not occur at those temperatures. A long period of gradually decreasing temperature—as in controlled cooling—or a period of constant temperature above that at which crack formation begins—as in the constant-temperature tests—was found effective in preventing the development of shatter cracks. As to the effects on the hardness of the rails, the following conclusions are noted:—First, placing rails in cooling boxes or holding them in a furnace at 900 deg. Fah. does not lower the Brinell hardness appreciably; secondly, placing them at 1100 deg. in cooling boxes packed with rock-wool insulation lowers this hardness by 5 to 10 Brinell numbers; thirdly, holding them in a furnace at 1100 deg. for five or six hours lowers the hardness by 25 to 30 numbers.

BEND TESTS FOR RAILS

As an acceptance test for rails the bend test has been known for some twenty years, but has not been included in any standard specification. Preliminary to any definite specification for this test, experiments must be made as to the effect of the length of span between the supports, and certain other details. Tests have been made therefore on rails of 90 lb., 100 lb., 110 lb., and 131 lb. per yard, with spans of 4ft., 4ft. 8in., and 5ft. 4in., and with head up and head down. The crosshead of the testing machine applied the load at two points, 12in. apart, or 6in. on each side of the centre line of the span. From the results of the tests, it seems desirable to use a 4ft. span for 110 lb. and 131 lb. rails. For 90 lb. and 100 lb. rails, 3ft. or 3½ft. span might be better, while for 152 lb. rails the span might be 5ft.

Experimental studies give evidence that a bend test using an autographic load deflection record gives a measure of the energy required for fracture not very different from that given by a single blow impact test to fracture. Furthermore, the bend test gives a measure of the strength of the rail—which is not determinable from drop-test data—and permits measurements of ductility and toughness. On the other hand, the drop test is merely a "pass or fail" test, and gives little indication of the relative merits of the rails which pass the test. After the first blow, the specimen is so distorted that the accurate determination of stress or energy under succeeding blows is not possible, while the relative effect of successive blows and one blow heavy enough to cause fracture is not known. In the drop-test machine also, a large amount of energy is absorbed in the springs supporting the anvil and not by the rail specimen.

HEAT TREATMENT OF RAIL ENDS

The application of various end-hardening processes, to enable rails to resist the battering action of wheels at rail joints, consists essentially in the application of heat-treatment principles. Maximum values of tensile strength were obtained at a Rockwell hardness of C: 52 (or Brinell hardness 461). Values of the reduction in area figures fell off rapidly when 52 was exceeded, while elongation values decreased more slowly. The toughness of heat-treated rails drops off rapidly when the value of Rockwell C: 48 (or Brinell 415) is exceeded, while hardness decreases as roughness increases. This steel loses strength, ductility, and roughness rather suddenly in the Rockwell range of C: 47 to C: 52, indicating that the usable hardness is exceeded when beyond C: 47. Thus the upper limit should not exceed C: 45. But hardness in end-hardened rails below C: 35 does not prevent wear and batter, so that the laboratory tests indicate a satisfactory range between C: 35 and C: 45.

No attempt should be made to evaluate the relative merits of various end-hardening processes on the basis of laboratory tests, since these tests do not include the effects of speed and other factors. Arrangements have been made therefore for service tests of end-hardened rails to determine both the relative merits of the different processes, and also the desirable depth of the end-hardened zone.

NON-DESTRUCTIVE TESTS OF RAILS

In previous vibration tests it appeared that better results would be obtained with more power applied to the test rail, giving increased amplitude of vibration. New vibrating equipment was therefore built and has given encouraging results. But they still indicate that some factors influence the damping of vibrations to a greater extent than any shatter-crack conditions, so that vibration tests will be discontinued unless some discovery is made that will clarify the situation. In the echo method of discovering discontinuities in the rails, a blow is struck on the end of the rail by a hammer, with the idea that if the rail contains shatter cracks the pattern of the primary pulse of vibration will contain superimposed secondary waves reflected from these cracks. Special equipment is being made for the echo tests, which were suggested by Mr. F. M. Graham, Assistant Engineer of Standards of the Pennsylvania Railroad.

These elaborate and comprehensive tests of rails and rail steels are arranged and financed jointly by the American Railway Engineering Association and the American Steel Rail Manufacturers' Association. The laboratory tests are being carried out at the University of Illinois, under the direction of Mr. H. F. Moore, Research Professor, assisted by representatives of the two Associations. The field tests are conducted by laboratory forces in co-operation with the railway companies and their engineering staffs.

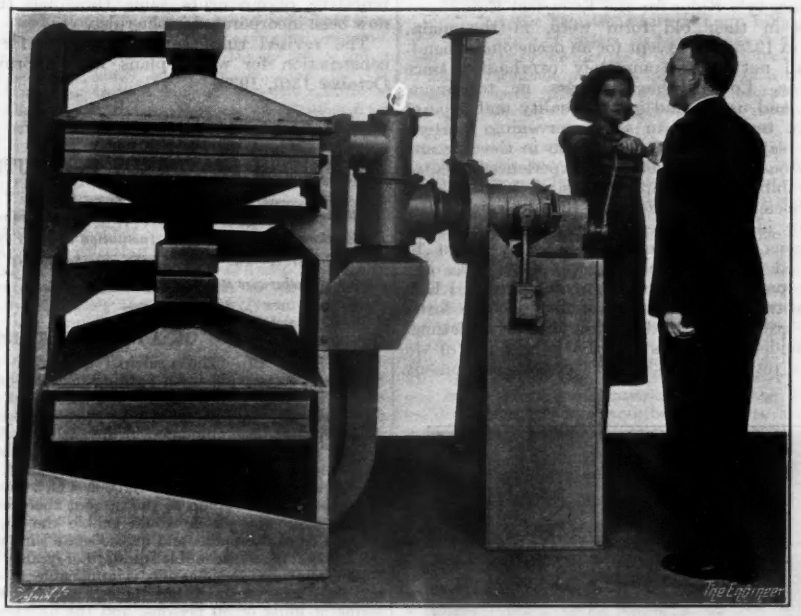
Ventilation and Anti-Gas Filtration Plants

WE have been supplied by Keith Blackman, Ltd., of Mill Mead Road, Tottenham, London, N.17, with some particulars of ventilation and anti-gas filtration plants which the firm has put on the market and which are intended particularly for use with A.R.P. shelters. The manufacturers point out that in a crowded shelter the air is likely to become moist and somewhat unhealthy within a comparatively short space of time if no means of ventilation is provided, and that in such circumstances people may find the use of gas masks very uncomfortable if not unbearable. By the installation of a ventilating

plant conditions can be greatly improved, and if filters are also included no need remains for the use of gas masks. Two types of plant are made by the firm. The larger, which is supplied in four capacities, is suitable for shelters holding from 25 to 100 people, and the smaller is intended to meet the needs of householders, small workshops, wardens' posts, &c. Some particulars of the larger type of plant are given in the following table :—

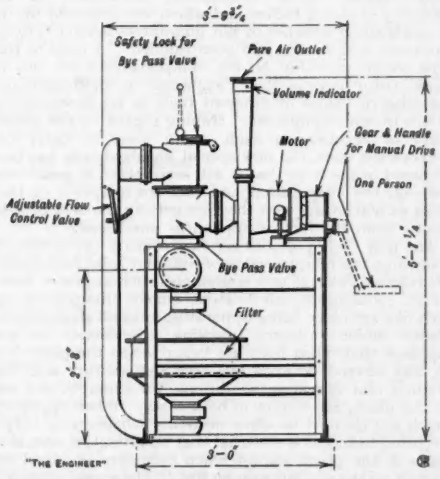
Designation	No. of Persons	No. of Filter Units	Fan Capacity
½ G.M.	25	1	3750 c.f.h.
1 G.M.	50	2	7500 c.f.h.
1½ G.M.	75	3	11,250 c.f.h.
2 G.M.	100	4	15,000 c.f.h.

The number of persons served is calculated on the basis of 2½ c.f.m. per person, and in each plant the filter unit used is the Sutcliffe Speakman Type A.



GAS FILTRATION AND VENTILATION PLANT FOR LARGE SHELTER

One of the larger plants is illustrated in an accompanying engraving. Both the 1½ and 2 G.M. units have the same specification, varying only in the number of filter units. Duplex filters are used capable of dealing with arsenical and all known poison war gases. They are mounted on a steel framework in a bank with inlets and outlets vertical. A steel sheet manifold connects them to the inlet pipe and to a bye-pass valve. Rubber sleeves held by steel clips form the joints between the units and the manifolds. For drawing the air through the filters a centrifugal fan is used, capable of delivering the quantities of air mentioned in the table against a pressure equal to 6in. of water. It is driven



ARRANGEMENT OF SMALL UNIT

through triple reduction totally enclosed gearing by a 0·4 B.H.P. 2850 r.p.m. electric motor. To provide for the possibility of failure of the electric current there is a shaft extension and a two-person driving handle can be used as shown in the engraving to keep the fan in motion.

In the air inlet pipe there is an isolating valve which, besides isolating the plant from the inlet pipe when not in use, also makes it possible to change a filter cell while the shelter is occupied without admitting possibly dangerous air from the exterior. The valve consists of a rubber-covered circular disc seating on a machined metal surface, and held firmly against the seating by the spring action of the valve plate. It is locked in position by a slotted bar and latch gear.

The fan inlet is directly connected to the filter inlet by the by-pass valve, which consists of a flanged welded steel body containing double seats of pure rubber and a weighted valve of steel and cast iron construction universally attached to its operating rod. Outside the top of the valve body there is mounted a hand operated cam which has a handle arranged to engage with a fixing pin that passes through the vertical operating rod. When in the bye-pass position, the valve is held tightly against the upper seat by a lock action produced by the manipulation of the handle cam on the pin passing through the vertical rod. Quick action to the gas tight condition sealing off the bye-pass is obtained by a slight push of the hand-operated cam and removal of the locking pin. The valve then drops to its lower seat, sealing being effected by its weight. A locking device into which the handle cam has to be pressed in order to allow for the attachment of a padlock is so designed that an additional positive pressure is applied to keep the valve sealed.

The plant is also equipped with a flow regulating valve, the function of which is to provide a means of controlling the volume passed through the filters when they are clean and of regulating it as the filter gets fouled. A flow indicator is fitted in the fan outlet taper pipe.

The arrangement of a ½ G.M. plant, the smallest size of that type, is shown by an accompanying

FOOT-OPERATED UNIT

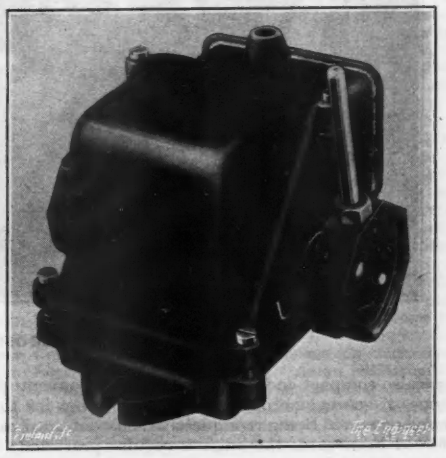
drawing, from which it will be seen that the design is similar but, in accordance with the reduced number of filter units, more compact. All four plants have the same height to the top of the outlet pipe—5ft. 7½in. The 1 G.M. plant has a similar arrangement with two filter units, whilst the 1½ G.M., and 2 G.M. plants are similar to that illustrated in the half-tone engraving above.

The firm also supplies an electric heater which can be fitted to the fan outlet pipe of these or any other similar plants. Normally it is designed to raise the temperature of the incoming air by 30 to 35 deg. Fah. The need for heating is stressed by the firm, since in the event of a raid occurring during the winter months people might have to leave well warmed rooms to enter shelters, and great discomfort would be caused were the ventilation plant to pour a stream of icy cold air over them. The need is even greater, of course, in decontamination posts where, of necessity, people will, for a time at least, be in a semi-clad or perhaps nude condition.

The other plants of smaller capacity which we mentioned at the beginning of this article are made in three sizes suitable for supplying the needs of 4, 8, or 12 persons. A typical example is illustrated in an accompanying half-tone engraving. The outfit consists of a filter unit capable of giving 800 hours service in war gas conditions, and giving protection against arsenic and other "smokes" and all known volatile gases, together with a fan mounted on ball bearings and driven through a free-wheel gear from a pedal. Between 30 and 35 strokes per minute are required to keep the fan running at the proper speed and balancing has been so carefully carried out that the set will continue running for about five minutes after the foot action stops. Unhurried changing of operators, if it becomes necessary, is therefore a simple matter. If desired the fan can be arranged to be driven electrically. The floor space occupied is about 2½ square feet and the weight, depending on the number of persons to be served, 60, 70, or 80 lb. As in the case of larger units there is a gravity-controlled bye-pass valve and an air flow indicator can also be fitted.

"Shunt" Limit Switches

THE recent reopening of three stations on the London underground railways marks the completion of the extensive programme of emergency work being undertaken by the London Passenger Transport Board in conjunction with the Ministry of Transport. It is well known that floodgates which can be closed across the entrances to the tunnels at these stations have been provided to enable the sections of the line which run under the river to be isolated in the event of an air raid, and so prevent extensive flooding should the tunnels be damaged. Each gate weighs six tons and slides into position in a cast iron framework. They can be operated either electrically or by hand and can be closed by power in one minute and by hand in 4½ minutes. The gates were made by



"SHUNT" LIMIT SWITCH

Glenfield and Kennedy, Ltd., of Kilmarnock, to the designs of Mr. W. T. Halcrow, consulting engineer, of Westminster.

In the control of the gates a small but important part is played by limit switches made by George Ellison, Ltd., of Perry Barr, Birmingham. The switches are used to cut off the supply to the driving motors when the gates reach the limit of their travel and to de-energise the solenoids of the magnetic brakes so that the gates come to rest quickly. Switches of this description also have other uses and are made dust proof, weather proof, and flame proof for service in explosive atmospheres. They are made with single, double, or triple poles and are self-resetting. The contacts will carry 40 amperes continuously and in the case of a single pole switch 10 amperes D.C. can be broken at 440 volts or 80 amperes A.C. at the same pressure. The breaking capacity of a double pole switch is roughly three times that of a single pole switch.

Although the switches may be used for a small motor circuit their normal duty is to energise a trip circuit or to interrupt the no-volt release coil of a circuit breaker. The tapper may travel at practically any speed and switches may be used for any number of consecutive operations up to 60 per minute. In the makers' test room a switch has been closed and opened 463,000 times at 80 operations per minute, equivalent to 5 to 6 years' service. As the moving

contact is in the form of a roller, there are no contact jaws to bend or soften. A toggle mechanism ensures firm contact and forcible separation. There can be no intermediate position of the contacts and no chattering.

If required, these "shunt" limit switches can be supplied with an insulated handle screwed into the hub for hand operation and the switches can be either self-resetting or hand resetting. The standard arrangement for cabling is a wood bush, but alternatively conduit can be used or cables can be led in either through Ellison cone clamps or through watertight glands. For such duties as that of reversing a small motor or service as a change-over switch on cranes or hoists a two way "shunt" limit switch is made.

Gas Booster Plant

AN accompanying illustration shows additional plant installed by a gas company in the south of England and provided by the Parsons Engineering Company, Ltd., of Southampton. The engines shown are Parsons six cylinder units developing 44 B.H.P. at approximately 1200 r.p.m. mounted on steel bedplates and provided with a well supported rope pulley at the flywheel end. The driven plants are Holmes-Connersville gas boosters used for augmenting the supply during rush hours. These engines are claimed to be particularly suited to the service as, being multi-cylinder vertical units, they are very smooth in operation and set up no vibration; they are also compact and compared with the conventional type of gas engine occupy very little room for their horsepower. Being completely self-contained and forced lubricated, the engines require practically no attention whilst running, and the special nature of the gas mixing valves together with the steady pull of the induction obviates the necessity for a gas bag. The usual gas governor on the main supply to the engines is all that is required. The engines are started by hand and are provided with magneto ignition with impulse drive.

GAS-BOOSTER INSTALLATION

Electric Pencil

AN electric pencil which has the advantage that it gives six degrees of writing strength has been put on the market by E. H. Jones (Machine Tools), Ltd., Edgware Road, The Hyde, London, N.W.9. The six different writing strengths are obtained by plugging the pencil into various combinations of four sockets in a special transformer which is provided as part of the complete equipment. This transformer, which is suitable for mains operating on 200 to 260 volts, steps down the voltage according to the grade of writing required and as the pencil uses only from 1 to 6 volts there is no risk of shocks to the operator. Where mains supply is not available the pencil may be operated on an ordinary 2 to 6 volt battery. Special heat resisting tungsten alloy is used in the manufacture of the writing needles and it is claimed that these needles retain their sharpness for far longer periods than the copper points generally used in similar devices. When the points have become burnt away and blunt they are easily resharpened on a fine abrasive wheel. Only a very light pressure, it is claimed, is needed to write on even very tough metals owing to the rapid vibration of the specially hardened needle. Where extra deep etching is required, the writing can be gone over a second time without ill effects. The complete equipment consists in addition to the pencil of the special transformer mentioned above and also a metal plate which is kept in contact with the work to complete the circuit. Where the pencil is required for battery operation the special transformer is not necessary.

Electrical Equipment of Ships*

THE Society's Rules for the Electrical Equipment of Ships in their old form were, in the main, adopted in 1925, and except for an occasional amendment had not been completely overhauled since that time. Considerable progress in technique, practice, and usage, and in the quality and type of materials, took place in the intervening fourteen years, to say nothing of the growth in the size and ramifications of installations, and experience indicated the desirability for a complete revision.

The Society kept before it the desirability for uniformity in rules and regulations affecting electrical installations in ships, and so that this might be maintained held up the overhaul of its rules and actively participated in the work of the I.E.E. Ship Electrical Equipment Committee. The latter recently issued the third edition of its regulations, and coincident with this was the publication of the Society's revised Rules for Electrical Equipment. It is interesting to note that the Society now has fully-qualified electrical engineer surveyors stationed at the principal building ports in the United Kingdom, and its influence and the steady improvement which is taking place in electrical installations in recent years are very marked.

It is not possible in a brief résumé to do justice to the whole of the amendments, as practically every section has been re-written, and it is only possible to indicate some of the more important items. Those intimately concerned with installations of this nature will be well advised to become acquainted with the new requirements, as, while they follow very closely best modern practice, they rule out some methods and materials which were possible within the letter of the old rules, but which have proved inadequate and can now be replaced by superior materials now available.

Special mention might be made of Section 15 which deals with the extra requirements for tankers. This section has been expanded to deal more precisely with the type of fitting permissible in various parts of a tanker, and also covers power circuits more completely.

Large equipments such as those of the "Queen Mary," "Mauretania," "Queen Elizabeth," and "Monarch of Bermuda" having, as has so often been said, sufficient generator capacity to supply a moderate-sized town, brought with them problems of distribution circuits and switchgear which the old rules were inadequate to cover. The sections on distribution and switchgear have therefore been re-cast to meet modern requirements.

Cables, always an important and expensive item, particularly in a large passenger vessel, have received special consideration, and it is important to note that several types are no longer permitted, such as tough rubber sheathing for permanent wiring, armouring without lead sheath, flat twin and three-core lead sheathed cables and all-rubber insulated cables having pure rubber next to the conductor.

In the generator section important changes in technical requirements have been incorporated, but it is worth noting, since the change-over will require very careful co-ordination, that in future the series winding is to be on the negative, as in land practice, and not on the positive. This practice also affects the switchgear in relation to the connection of ammeters, overload trips and reverse current trips.

Fluorescent tube lighting is now common in passenger vessels, and although the Society issued tentative requirements some time ago they have now been incorporated in the rules.

The revised rules came into force for all new construction for which plans were approved after October 13th, 1939.

*Contributed by Lloyd's Register of Shipping.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

LIGHTING OF A.R.P. SHELTERS

(B.S./ARP 26).—The principal object of this specification is to provide for a lighting installation from the mains, together with a battery and associated equipment for emergency use, at an overall price of approximately 5s. per person accommodated in the shelter. An installation at about this cost but deriving the lighting entirely from batteries, with other batteries in reserve, is already provided for in part 1 of B.S./ARP 6, which was published some time ago; but up to the present there has been no standard scheme which would enable the supply to be derived from the mains and at the same time provide for reserve and for a reasonable standard of quality at this low cost. The new specification is applicable to shelters of any size, large or small, but the equipment is specified in terms of units of 50 persons, and the estimated cost of 5s. per person has been based on prices for a 50 person shelter. Incidentally, this figure does not include an allowance for the cost of bringing the main supply to the shelter. The lighting is at 12 volts, derived from the mains through a transformer, or from a battery through a change-over switch. Four lighting points are to be provided for every 50 persons, these being wired as two sub-circuits; normally both sub-circuits are supplied from the transformer, but under emergency conditions one of the sub-circuits can be switched over to the battery. Details are given of the wiring, lamps, switches, fuses, transformer, batteries, and spares. Copies of this specification may be had from the British Standards Institution, 28, Victoria Street, S.W.1, price 3d. post free.

COMMERCIAL TESTING OF SMALL STEAM RAISING PLANTS

(B.S. 878).—It will be recalled that a British Standard Code for Commercial Acceptance Tests for Steam Boilers was issued in June of last year, which provided for the determination, under commercial conditions, of the efficiency of steam boilers and which was intended for use in establishing whether or not guarantees agreed between purchaser and vendor had been fulfilled. A code of that type would probably be too comprehensive for use by small steam users in their own works or for determining the relative values of different fuels or for assessing the values of new equipment. Having regard to the desirability of encouraging such steam users to carry out evaporation tests, the new special abridged code has been prepared in the hope that it will assist them to make such tests on the evaporation and fuel consumption of their plant as will ensure that they are getting the best possible results from the fuel or appliances purchased.

The new Code provides for the carrying out of tests to determine the relative value of different solid fuels and/or the relative value of new equipment, such as grates, circulators, economisers, air heaters, smoke eliminators, and such like auxiliary boiler apparatus, in small steam-raising plants under ordinary working conditions. It presupposes that when fuels are being tested the plant is in no way altered between one test and another and that running and operating conditions, for example, the load on the plant, are similar in both cases. When appliances which are claimed to affect economy efficiency or output are being tested, it is essential that no alteration should be made to the plant, except when necessary to instal and connect up the appliance under test. The actual conditions which exist before the appliance is put into use should be ascertained by testing the plant in a manner similar to that to be adopted when the appliance is tested. The code has been so prepared as to render an analysis of the fuel or of the flue gases not essential. Provision for dealing with these matters has, however, been made in an appendix and it is recommended that wherever possible this additional information should be obtained.

HAND HAMMERS

(B.S. No. 876).—This specification has been issued in close co-operation with the Edge Tools Manufacturers' Association. It deals with joiners', engineers', smiths', stonebreakers', and boiler scaling hammers. The specification was prepared at the request of the Institution of Mechanical Engineers and is intended to cover all the hand hammers in general use. Both form, dimensions, and weight are dealt with and requirements are included governing the quality of the material used, together with practical tests on the hammer, &c.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

New Iron and Steel Prices

An order has been issued by the Minister of Supply entitled the Control of Iron and Steel (No. 6 Order), which will have the effect of raising the prices of all descriptions of iron and steel. The Order came into force on February 1st, and supersedes the Control of Iron and Steel (No. 4) Order made on November 1st, 1939. In substance the previous order is unaltered, but the scope of the provisions for exemption from licence has been narrowed. The maximum prices fixed under the Order represent an addition of 3s. per ton in the case of pig iron, and £1 in the case of semi-finished and heavy steel products, with corresponding adjustments in the prices of other finished products. These additions are made for the purpose of meeting from a central fund the additional costs including higher freight charges, which arise from importations of raw and semi-finished materials under war conditions. Further adjustments have also been made in the prices of tinplates and iron castings. The new prices will be given in our "Current Prices for Metals and Fuels" in next week's issue of THE ENGINEER.

New Aluminium Order

An Order affecting the importation of aluminium, to come into force on February 1st, was issued on January 24th. The announcement states that at the request of the Ministry of Supply the Board of Trade has issued an Order, the Import of Goods (Prohibition) (No. 3) Order, 1940, prohibiting, except under licence, the importation of aluminium and alloys thereof containing more than 50 per cent. by weight of aluminium (whether coated or plates or not) other than machinery parts, in the form of ingots, notch bars, lumps, cakes, sticks, billets, slabs, wire bars, plates, sheets, strip, circles, discs, flat stampings, bars and rods, angles, shapes and sections, tubes, wire, cable, foil (whether backed with other material or not), flakes, granules, scrap and old metal; aluminium and aluminium alloy waste or dross. The Order will come into operation on February 1st, but goods covered which were despatched to the United Kingdom before the Order comes into force will not require a licence. The object of the Order is to assist in regulating the supply of aluminium alloys and aluminium scrap in the form listed above so that the needs of the Services are satisfied, the export trade is maintained as far as possible and metal is available to produce certain essential goods for home industries, while limiting for exchange reasons the import of aluminium in these forms for non-essential purposes. Whilst the granting of licenses will depend on the circumstances of each case and the conditions ruling at the time, applications to import such materials for the manufacture of goods for export will generally be allowed. No licences will be issued for the import of aluminium foil, which is defined as sheet, strip, &c., not exceeding 0·006in. in thickness, and applications for licences to import alumium sheet and strip should specify thickness. The importation of aluminium powder has already been prohibited except under licence. Licences will be issued by the Import Licensing Department of the Board of Trade on the recommendation of the Aluminium Controller, Ministry of Supply. Applications for import licences must accordingly be submitted in duplicate direct to the Aluminium Controller, Ministry of Supply, Raven Hotel, Shrewsbury, Shropshire. Application forms may be obtained from the Import Licensing Department, Board of Trade, 25, Southampton Buildings, Chancery Lane, London, W.C.2, and the offices of H.M. Customs and Excise. The direction at the head of the application form that it should be forwarded to the Import Licensing Department should be ignored. After the application has been examined by the Aluminium Controller he will pass it to the Import Licensing Department who, in approved cases, will issue and send the licence direct to the applicant.

The Pig Iron Market

The position in the pig iron market is as comfortable as that department of the iron and steel trades could be at any time during a state of war. The demand for steelmaking iron is phenomenal and in spite of all efforts to increase supplies the requirements of the steelworks are in excess of production. Imports of basic iron are expected to relieve the situation, and in any case by the carefully regulated system of distribution the output of the steelworks is well maintained. The situation in the foundry iron market is somewhat irregular, since the demand is largely from the engineering industries and there is still a considerable amount of unemployed plant at the light castings foundries. Consumers appear to be reconciling themselves to the scarcity of Cleveland No. 3 iron and in fact seem to be doing very well without it, since the light castings foundries on the North East Coast are receiving full supplies of Midland and Staffordshire irons. Most of the pig iron producing plants on the North East Coast are making basic iron, principally for associated steelworks. Midland consumers are receiving sufficient supplies of pig iron to enable them to work full time on Government orders. The demand is still largely for low phosphoric grades and the production of this class of material seems to have expanded lately. There is no large surplus, however, when the needs of the consuming industries have been satisfied. High phosphoric iron is in lesser demand as the principal users are the light castings founders who are not in full employment, although there is a gradual absorption of the capacity of this section of the industry into work of national importance. The decline in the requirements of the building trade, however, has left a certain amount of plant in most districts with rather slender order books. This is more noticeable amongst the Scottish founders and as a result the demand for pig iron is irregular. The heavier requirements of the Scottish steelworks ensure the maintenance of the demand for basic steel and the makers buy freely all available quantities whether from home or imported sources. Buying by the foundries, however, is on the quiet side owing to the restricted requirements of the light castings makers. Business in hematite pig iron has been active, and the stocks at the furnaces have been considerably reduced since the year commenced. Licences for the purchase of this description of iron are carefully scrutinised and the distribution is systematically regulated, with the result that consumers have little to complain about. There is also a heavy demand for special quality irons for the manufacture of special steels.

Scotland and the North

All the Scottish steelworks are fully employed and the reserve of orders on their books is sufficient to keep them busy for months. The great bulk of the work is for Government purposes and orders of a commercial character have little chance of being accepted for any definite delivery. The steelworks are receiving good supplies of raw materials; but they are anxious to secure more scrap, the position in regard to which is causing some concern. Arrangements are being made, however, to supplement home supplies which are often insufficient to satisfy the full requirements of the steelworks, with imports from other countries. The heavy steelmakers are meeting with such an insistent demand that their capacity is being taxed to the utmost, and they are falling into arrears with their deliveries. In these circumstances extended dates are quoted for all new business, even in the case of consumers in the priority categories, and this is particularly noticeable in the case of heavy plates. There seems little likelihood that there will be any relaxation in the pressure to obtain material. The shipyards in particular are taking heavy tonnages and other consuming industries such as the locomotive builders, tank makers and boiler makers are equally eager to secure supplies. As all the shipyards are fully employed the demand for all classes of shipbuilding steel is exceptionally strong and the works are hard put to it to keep abreast of consumers' needs. Large tonnages of joists, light and heavy, and sections of all sizes are passing to the constructional engineers. Past weather conditions had the effect of slowing down work on some jobs, and this afforded slight relief to the steelworks. Another branch of the consuming industries which is fully occupied is the marine and general engineering establishments, which almost without exception are fully engaged upon Government work. The Scottish tubemaking department is also working full time and absorbing large supplies of strip. The re-rolling industry is in a better position at the moment than for a long time past, as substantial supplies of billets have been received, and as a result the works have been able to concentrate upon reducing some of the backlog of orders. In the Lancashire market there is an unrelaxed demand from all classes of consumers for light and heavy descriptions of steel. The constructional engineering firms in this district are taking large supplies of joists and sections and the platemakers are so busy that it is difficult to place orders for any reasonable delivery. The demand for all classes of bars, particularly concrete reinforced descriptions, shows no signs of diminishing and the engineering industries are calling for large supplies of special and bright drawn steel.

The Midlands and South Wales

The steelworks in this district are operating under intense pressure. So far from the demand relaxing it appears to increase week by week as fresh Government orders are given out. All available plant is now in operation and it is hoped that some further units which in ordinary circumstances would be regarded as obsolete may yet be brought to serve a useful purpose. Past weather conditions brought about a slackening in the consumption of steel by some of the constructional engineering concerns, but nevertheless the heavy steelworks are being pressed to the utmost to give deliveries of bars, joists, and sections. Production is at a high rate, but as a result of the increasing requirements of consumers, supplies to the works are getting into arrears. With the approach of the spring the demand from the constructional engineers is likely to expand, most of them being engaged upon Government contracts which will require large tonnages of steel. Considerable quantities are also going to the shipyards, which are fully employed upon national work. The plate mills have been working at capacity for some weeks, and have enough business in hand to keep them occupied until late in the year. Consumers of this class of material are particularly busy, especially the boiler makers, locomotive builders, and tank makers, who have an important programme of work in hand. The re-rollers in the Midlands, who before Christmas received good supplies of semi-finished steel, suffered as a result of the severe weather conditions which prevailed recently. In many cases supplies reach the works by water transport over canals and this traffic was interrupted. They are, however, in many instances in a better position than at the close of the year and their production is immediately taken up. Expectations that shortly larger supplies of billets and sheet bars will be available lead to the hope that it will be possible to reduce some of the arrears in deliveries accumulated during the period of scarcity of those materials. In the South Wales market the iron and steel industry is actively employed; but the shortage of steel and tinplate bars is affecting operations at some of the tinplate works. This industry has orders for between ten and eleven million boxes in hand, and there is a good demand both on home and overseas account. The industry is employed at about 74 per cent. of capacity, which compares with about 41·70 per cent. a year ago. Although the output of soft steel billets is on a heavy scale, it is absorbed by the re-rollers immediately, and the demand is not fully met even with the help of imported material.

Overseas Trade Opportunities

The Department of Overseas Trade, Gt. George Street, London, S.W.1, announces that the following contracts are open for tender. The closing date is given in parentheses and local representation is essential in all cases: India, Eastern Bengal Railway Administration: 43 locomotive boilers (extended to February 12th). South African Railways and Harbours Administration: Supply and delivery of structural steelwork for a 600-ton coaling plant for Pietersburg (Johannesburg, February 5th). Egyptian Ministry of Public Works, Main Drainage Department: Quantities of heavy cast iron pipes, junctions and bends (spigot and socket) and air stop valves (Globe pattern) (Cairo, February 6th). South Africa, Union Tender and Supplies Board: Supply and delivery of 15,000 lb. of lead sheets, 6 lb. per square foot (Pretoria, February 8th). Johannesburg, Stores Dept.: Oil purifiers (Johannesburg, February 10th). Egypt: Ministry of Communications: Engine and water pump for Shedwan Lighthouse (Red Sea) (Alexandria, February 10th). New Zealand Posts and Telegraphs Dept.: Supply and delivery of 300 copper earthplates (Wellington, C.I., February 12th). South African Railways and Harbours Administration: steel superheater flue and boiler tubes (Johannesburg, February 12th): one 42,000 gal. capacity pressed steel tank (32ft. by 28ft. by 8ft. deep, open top) together with 22ft. high tower (Johannesburg, February 23rd. Municipality of Robertson, Cape Province: Supply and delivery f.o.r. Robertson Station of pipes, valves, and fittings with necessary jointing material (Town Clerk, February 12th).

Copper and Tin

When the war broke out and control in this country was first established complaints were made that it was a mistake to peg the price at so much below the world market level. On the other hand it was suggested that the world price would tend to drop from the high figures which at first ruled. This latter school of thought seems to have been correct and the world price, including the American domestic price, has been drifting downwards for the last week or two. The official American export quotation is now just over 12c. but actually offers well below this have been received. For the most part the decay in the price structure has been the result of the customs smelters accepting lower bids. This, however, is usually the way in which a decline in the American copper price commences and there are indications that some of the larger companies are now prepared to accept business at less than 12c. Buying by neutrals has been much quieter of late and this has helped the downward movement. Italy and Japan have been in the market, and the Anglo-French Commission has also bought copper in the United States for delivery in France. Amongst countries which have shown interest in the market has been Switzerland, from which country a large inquiry has been issued. According to figures issued by the American Bureau of Metal Statistics the estimated smelter production in 1939 was 2,331,500 tons compared with an output of 2,195,755 tons in 1938. The consumption is put at 2,284,000 tons in 1939, and 1,975,700 tons in 1938. Reports that Great Britain has been buying additional supplies apart from Empire sources are extremely improbable and similar rumours that the Control may reduce the price are reported as unlikely since the British official maximum is well below world parity. . . . An easier tone has been apparent in the tin market. This is the result largely of steady selling by the producers of English tin. Last week the expected announcement was made by the Tin Control that export licences would be more easily granted and that tonnages would be released for the United States. The American response however has been poor and consumers in that country are apparently sufficiently well covered to disregard the implied invitation to buy more tin in this country. The general opinion seems to be that little buying can be expected from America for some time to come, and that the consuming industries there have if anything overbought. As an indication of the disorganisation of the world tin market caused by the war, whilst prices in America and this country have been receding quotations in Scandinavia have been advancing. In other Continental countries also the price is higher than in Great Britain.

Lead and Spelter

There is a heavy demand for lead from consumers engaged upon war work, but the call for other purposes appears to be diminishing. This may to some extent be due to the knowledge that manufacturers producing ordinary commercial materials do not find it easy to obtain the necessary licences as, whilst there seems to be sufficient metal to keep the war industries well supplied there does not appear to be any surplus for ordinary trades. Applications for licences are carefully considered and so far as can be seen no consumer engaged upon national work has had to go short. Some peace time industries are not well off as regards orders. The decline in the activity of the building trade is responsible for a slackening in the demand in some directions, whilst it is understood that there has been a decline in the amount of lead taken by the paint makers. The high prices which ruled in the world market in the early days of the war appear to be definitely a thing of the past, and there is not much difference now between the price ruling in some countries—Belgium for instance—and the British maximum price. . . . Little change has been noticeable in the spelter market for some weeks. In this country whilst some economy is observed in regard to the distribution of supplies there is no lack of metal for ordinary requirements. There is apparently some scarcity of high grade spelter, but G.O.B. brands are freely offered. The supplies of foreign G.O.B. spelter are rather scarce, but this is not surprising since none of this description has been imported since the beginning of the war. In the world spelter market as in the case of other non-ferrous metals, the price has declined and is now not much above the British official quotation. Prices, however, seem to vary rather widely in neutral countries. Belgian smelters are reported to be running short of supplies of concentrates.

French Engineering Notes

(From our own Correspondent in Paris)

Franco-British Trade

THE question arises whether British engineering firms should prepare now to take advantage of the favourable position in which they are placed by a changing economic system which is developing in the direction of a new order of international trade. On the one hand, Germany is endeavouring to obtain by conquest a hegemony over States that will bring under her control all resources that make for self-sufficiency, and, on the other hand, France and Great Britain have pooled their resources for the prosecution of the war in a manner that opens up new possibilities for trade exchanges in the future. After the last war, France tried every expedient to protect her economy in a disorganised world, and her experience of failures and, at the best, of negative results brought her back to orthodox theories of political economy that resolved themselves into a policy of reciprocal trading that could not be fully applied so long as there existed the most favoured nation clause. It often worked indifferently through failure of countries to fulfil reciprocal obligations. Moreover, little could be done so long as some countries were unable to offer sufficient concessions in exchange for advantages claimed from other countries. The rigidity of the reciprocal system must be relaxed if it is to become an expanding factor in international trade. It was on account of these difficulties that France tried to abandon methods of protection that had produced an increasingly heavy adverse balance of trade. A national campaign was organised three years ago in favour of developing exports, and the then Minister of Commerce declared that the Government would be obliged to leave to their fate industries that could not exist without costly protection. The great bulk of imports were raw materials, and exports of manufactured goods were wholly insufficient to pay for them, so that the policy now adopted is to utilise as much as possible raw material resources within the Empire and make an effort to expand exports of specifically French goods in exchange for a wider range of other manufactured goods. It remains to be seen how these plans will work out in view of the necessity for adjusting industry to meet new conditions. Nevertheless, the general lines of a post war economic policy are sufficiently clear to indicate a much wider expansion of foreign trade. It is for this reason that the Paris Trade Fair in May next offers a means of demonstrating a Franco-British industrial solidarity that would be of great importance in future foreign trade relations. The Fair will be held as usual at the instigation of the Minister of Commerce, and it is hardly possible to say at present how far the machinery sections will be affected by the pressure of armament activity, but every effort will be made to give a special character to the Fair, if possible by the presence of a larger number of British exhibitors. Last year, German firms occupied one half of the machine tool section, as well as being represented in oil engines and public works machinery. Notwithstanding disturbed conditions, the Fair should be a success, and a British participation would be of undoubted value now that France is at one with Great Britain.

Safety of Ships

The decree published two months ago prescribing measures that must be taken to reduce the risk of ships sinking through damage from torpedoes or mines has been supplemented by another decree requiring that all French mercantile ships navigating in the Channel and in the North Sea shall carry rafts sufficient to accommodate all the persons on board. The rafts are of the regulation type capable of being launched off the ship in whatever position she may be and of automatically righting themselves. Among inventions that aim at preventing ships from sinking is one by the Russian engineer Monsieur Yourkevitch, who designed the "Normandie" hull. As torpedoes or mines explode on impact with the hull and plates are torn outwards, the hull is prevented from being flooded by keeping air under pressure in the holds and maintaining it against the water pressure by air pumps. The holds are made airtight by a specially prepared rubber sheeting. No particulars are yet known of the invention or of the installation and importance of the air compressing plant, but as Monsieur Yourkevitch is said to have gone to the United States to see about its exploitation there is presumably reason to believe that something more may be heard of the invention.

Dams in North Africa

Algeria and Morocco provided experience in the construction of dams that was of value to French engineers when they had to deal with more complicated problems at home. The mountain ranges along the southern part of Algeria that extend through Morocco feed innumerable small rivers that are usually dry during the greater part of the year and the supply is irregular from one year to another. So long as there was no means of impounding water those countries suffered from long periods of drought that seriously compromised cultivation and left towns with inadequate supplies. North Africa could only be fully developed by impounding water in valleys with dry river beds down which came torrents in the late winter. The violence of these torrents was not at first taken sufficiently into account when constructing dams, and the collapse of a large dam in Algeria many years ago was one of the experiences that helped to improve methods of dam construction. The building of dams is the first preoccupation of the public works' services, and the work of impounding water is continuous, generally for irrigation. In Algeria two dams have recently been raised and reinforced and three others are nearing completion, including the Zardezas dam which will supply the town of Philippeville. The Béni-Bahdal dam, to be completed early next year, will supply 60,000 cubic metres of water a day to Oran and the naval base of Mers-el-Kébir by a main 111 miles long. Another large dam, the Bou-Hanifia, is expected to be finished in 1942. As the reservoirs are generally fed by occasional supplies there is little production of electrical energy.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

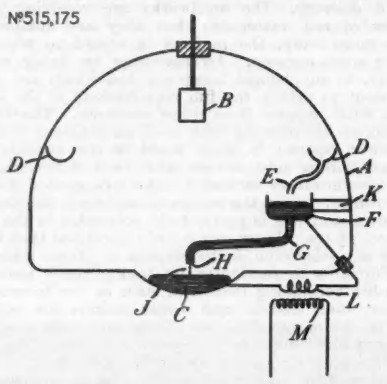
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

TRANSFORMERS AND CONVERTERS

515,175. May 26th, 1938.—MERCURY ARC CONVERTERS, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2, and Henry Thomas Ramsay, of Research Laboratories of The General Electric Company, Ltd., Wembley.

This invention relates to mercury arc converters in which means are provided whereby the point in each cycle of the A.C. input at which the arc starts can be controlled by an electrical signal. The accompanying drawing shows diagrammatically a section through a converter. A is the steel envelope, B the



anode within it, C the cathode pool at the bottom. D is a channel on the envelope collecting mercury condensing on the upper part, E a tube through which the mercury drips into the container F. Thence it flows through the tube G and issues from the orifice H in the jet J. The container F is supported from the wall by an insulating member K, and is connected to the cathode through the secondary L of a step-down transformer to whose primary M the electrical signal is applied. The current provided by this transformer is sufficient to break the jet by the pinch effect; the breaking of the current then starts an arc.—*November 28th*, 1939.

BUILDING

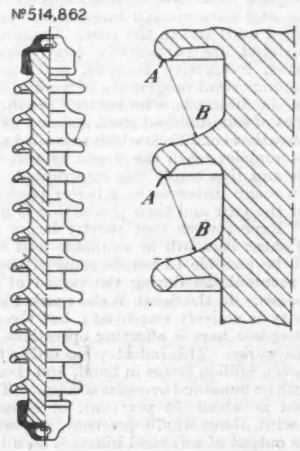
515,003. May 17th, 1938.—IMPROVEMENTS IN REINFORCED CONCRETE, Nicolas Zitkevic, 30 Gladston Strasse, Belgrade, Yugo-Slavia.

In order to obtain concrete with a greater tensile and shearing strength according to the invention it is reinforced by the addition of pieces of thin, flexible, soft iron wire 10–15 cm. long and substantially 1 mm. in diameter, which are uniformly distributed throughout the mass. The nature of the flexible soft iron wires is such that they become deformed during mixing and conform themselves to the shape of the stone ballast in the concrete. The method of constructing buildings of wire-reinforced concrete is as follows: The prepared plastic concrete of definite composition has added to it a certain quantity of cut flexible soft iron wire of about 1 mm. thickness, and of a length of 10–15 cm., which is uniformly distributed in the concrete mass before pouring the concrete on to the structure. A suitable mixture of wire and concrete is formed by the addition of 50 Kg. of pieces of flexible soft iron wire, of 1–1·2 mm. diameter and 10–15 cm. length to 1 cubic metre of concrete containing 400–600 Kg. of cement per cubic metre. The wires are drawn out evenly by means of forks on to the surface of each rammed layer of concrete so that a strong union with the next layer of concrete is obtained; the length of the pieces of wire enables a sufficient quantity to extend into each of the adjacent layers to provide a secure union between said layers.—*November 23rd*, 1939.

MISCELLANEOUS

514,862. May 17th, 1938.—ELECTRIC INSULATORS, Brown, Boveri and Cie, Aktiengesellschaft, of Mannheim 2, Germany.

The invention relates to electric insulators that consist of a long, solid ceramic cylindrical stem provided with petticoats for protection from the rain, and it relates particularly to an advantageous construction of the petticoats. The petticoats are formed about the cylindrical stem of the insulator, the



upper surface of any petticoat except the uppermost being formed by a generatrix that is the arc of a circle struck from the lowermost point A of the drip edge of the petticoat above. Further, the position of the petticoats upon the stem is determined by ensuring that the upper surface of the petticoats meets the periphery of the cylindrical stem at the point at which the straight line forming the radius B is disposed at an angle of 45 deg. to the axis of the insulator.—*November 17th*, 1939.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Bradford Engineering Society

Monday, Feb. 5th.—Technical College, Bradford. "Impact and Notched Bar Testing," C. N. Waterhouse. 7.30 p.m.

Chemical Engineering Group

Friday, Feb. 16th.—Chemical Society's Rooms, Burlington House, Piccadilly, W.1. "The Chemical Plant Manufacturer in Relation to Chemical Industry," B. N. Reavell and G. E. Foxwell. 2.30 p.m.

Diesel Engine Users' Association

Thursday, Feb. 8th.—Caxton Hall, Caxton Street, S.W.1. "Oil Engine Driven Pumping Plant at the Dunswell Pumping Station of the Hull Corporation," C. Green. 2.30 p.m.

Institution of Automobile Engineers

Tuesday, Feb. 6th.—Royal Society of Arts, John Street, Adelphi, W.C. 2. "The Instrumental Attack on Automobile Noise," D. B. Foster. 6 p.m.

Tuesday, Feb. 13th.—Luton Centre. George Hotel, Luton. "Some Anti-Friction Bearing Problems," M. J. Knaggs. 7.30. Coventry Centre. Kings Head Hotel, Coventry. "The Theory of Flexible Mountings for Internal Combustion Engines," C. B. Iliffe. 7 p.m.

Wednesday, Feb. 14th.—Manchester Centre. Engineers' Club, Albert Square, Manchester. Informal Discussion. 7.15 p.m.

Institution of Chemical Engineers

Tuesday, Feb. 13th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "Sedimentation and Flocculation," M. B. Donald. 2.15 p.m.

Institution of Electrical Engineers

To-day, Feb. 2nd.—N.E. Students' Section. Newe House, Pilgrim Street, Newcastle-upon-Tyne. Chairman's Address, H. G. A. Stedman. 7 p.m.

Wednesday, Feb. 7th.—Wireless Section. Savoy Place, Victoria Embankment, W.C.2. "Analysis of the Effect of Scattering in Radio Tranamission," T. L. Eckersley. 6 p.m.

Thursday, Feb. 8th.—Savoy Place, Victoria Embankment, W.C.2. "Telegraphic Typesetting," H. H. Harrison. 6 p.m.

Institution of Electronics

Thursday, Feb. 8th.—Royal Society of Arts, John Street, Adelphi, W.C.2. "Phosphorescent Phosphors," L. Levy and D. W. West. 6 p.m.

Institution of Mining Engineers

Saturday, Feb. 10th.—Royal Victoria Station Hotel, Sheffield. Annual General Meeting. Presidential Address, E. O. Forster Brown. "Mine Supports during War Time," A. M. Bryan, M. A. Hogan, and J. A. S. Ritson. 11 a.m.

Institution of Production Engineers

Tuesday, Feb. 13th.—Birmingham Graduates. James Watt Memorial Institute, Birmingham. "Metal Cutting Fluids," C. F. Gazard. 7 p.m.

Wednesday, Feb. 14th.—Preston Section. Harris Institute, Corporation Street, Preston. "Progress in Machine Tool Design," R. C. Fenton. 7.30 p.m.

Junior Institution of Engineers

Friday, Feb. 9th.—39, Victoria Street, S.W.1. "The History and Development of Lubricated Plug Valves," P. Meredith. 6.30 p.m.

Manchester Association of Engineers

Friday, Feb. 9th.—College of Technology, Sackville Street, Manchester. "The Use of Models in Engineering," A. H. Gibson. 7.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Feb. 2nd.—Technical College, Sunderland. "Recent Developments in Shipbuilding and Marine Engineering," W. Muckle. 6.45 p.m.

Friday, Feb. 9th.—Mining Institute, Newcastle-upon-Tyne. "The Application of the Heavy-Oil Engine to Aircraft Propulsion," W. S. Burn. 6 p.m.

Royal Institution of Great Britain

Monday, Feb. 5th.—21, Albemarle Street, W.1. General Meeting. 3 p.m.

Tuesday, Feb. 6th.—21, Albemarle Street, W.1. "Present-Day Study of the Stars," Sir James Jeans. 3 p.m.

Wednesday, Feb. 7th.—21, Albemarle Street, W.1. "X-ray Optics," W. L. Bragg. 5.15 p.m.

Thursday, Feb. 8th.—21, Albemarle Street, W.1. "Measurement of Gravity," A. O. Rankine. 3 p.m.

Friday, Feb. 9th.—21, Albemarle Street, W.1. "Ultra-Violet and Electron Microscopy," L. C. Martin. 5 p.m.

Society of Engineers

Tuesday, Feb. 6th.—Royal Empire Society, Northumberland Avenue, W.C.2. Luncheon. 12.45 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

J. H. FENNER AND CO., Ltd., Hull, power transmission engineers, have opened a branch at 73, Robertson Street, Glasgow, under the management of Mr. J. M. Russell, who has been their principal representative in Scotland for some years.

MR. CLARENCE G. STOLL has been elected president of Western Electric Incorporated of America, in succession to Mr. Edgar S. Bloom, who recently retired. Mr. Stoll has been vice-president in charge of operations. He has spent his entire business career of 36 years with Western Electric, having started as a student apprentice.

THE ASSOCIATED EQUIPMENT COMPANY, LTD., Southall, Middlesex, has opened a new Sales and Service Depot in Brook Street, Nottingham. This depot replaces the premises which have been occupied by the area manager and his staff since 1931. The building covers over 80,000 square feet, and is the largest of the company's provincial depots.

DENNY, MOTT AND DICKSON, Ltd. have received an appointment from the Admiralty to act as its agents in connection with the supply and distribution of timber to Admiralty contractors and sub-contractors. This appointment has necessitated the return of the firm's London office to Adelaide House, King William Street, E.C.4.